Gibbons

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THE Association was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over 1000 men. Its membership is divided into six classes, viz.:

A Member shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

An Honorary Member shall be a person of acknowledged eminence in some branch of water supply or of engineering.

A Junior shall be not less than eighteen years nor more than twenty-five years of age, a student or connected with water supply work.

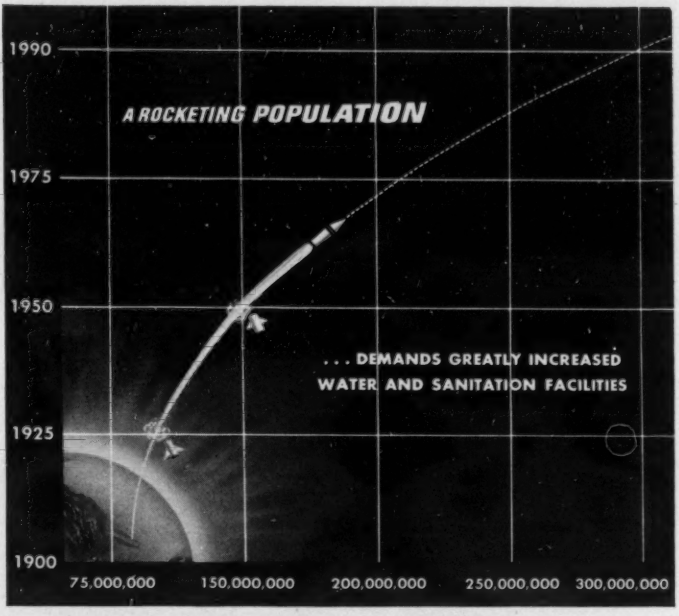
An Associate shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

A Corporate Member shall be either a Water Board, Commission, Company or Municipal Corporation.

The initiation fees and annual dues are as follows:

	Initiation Fees	*Annual Dues*
Members	$ 2.00	$ 2.00
Juniors	1.00	3.00
Associates	10.00	25.00
Corporate Members	10.00	15.00

This Association has at least eight regular meetings each year, of which five are held in Boston, one in northern New England, one in southern New England, and one, the annual convention, held in September or October on such date as the Executive Committee may designate.



Growth of U.S. Population in Millions:

1900—75; 1950—150; 1990—300 (Estimated)

And proportionate demands on water and sanitary facilities are increasing even more rapidly because of industry's ever-growing need for water supply and waste disposal.

Over the past half century Lock Joint Pipe Company has helped keep pace with the requirements of a doubling population by supplying millions of feet of concrete pipe for vital water and sewer lines. Virtually 100% of these are still in service and are operating with the same high efficiency as the day they were installed.

This unexcelled record for economy, efficiency and safety certainly recommends Lock Joint Concrete Pressure and Sewer Pipe as the ideal material to implement the long range plans of water and sanitation officials to meet the growing crisis.

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Sales Offices: Chicago, Ill. • Columbia, S. C. • Denver, Col.
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Pressure • Water • Sewer • REINFORCED CONCRETE PIPE • Culvert • Subaqueous

Vol. 7
1960

THE MARK OF THE 100-YEA

PERMANENTLY YOURS: CAST IRON PIPE

Installed—
it stays installed

One thing sure about cast iron pipe—once it's in the ground, it's there for keeps! Over 100 American utilities, having used cast iron pipe steadily for more than a century, can testify to that. And *modern* cast iron pipe gives you greater assurance than ever: great beam strength resists heavy surface traffic; tremendous load resistance absorbs even the most forceful pressures. In fact, when you select cast iron pipe, you can anticipate no major repairs in your water supply system for the next hundred years!

Cement-lined—it stays cement-lined

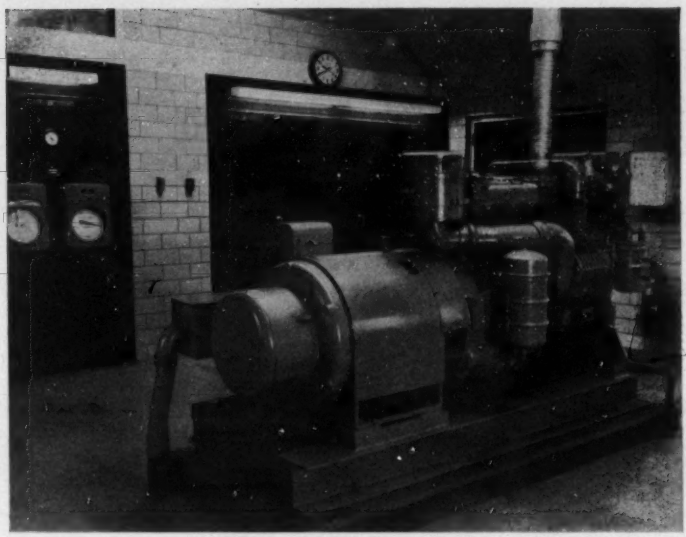
A smooth coat of cement lining along the inner wall helps prevent the formation of flow-reducing particles. No matter how strong the water is, cast iron pipe always assures a free, steady flow.

Joined—it stays joined

Bottle-tight, rubber-ring joints give you leak-proof protection at the most vulnerable points of your system. Vibrations, surface traffic and washouts present no problems to cast iron pipe. Inherent ruggedness . . . built to perform under all adverse underground conditions . . . repair-free service for at least a century—all good reasons why your choice should be that of water utility experts everywhere. America's greatest water carrier: cast iron pipe.

Cast Iron Pipe Research Association,
Thos. F. Wolfe, Managing Director,
3440 Prudential Plaza, Chicago 1, Ill.

CAST IRON PIPE



Diesel Generator Set
Brunswick and Topsham Water District
Brunswick, Maine

This 125 KW CUMMINS Diesel Generator Set provides stand-by power at Taylor Farm Supply, Brunswick and Topsham Water District. The generator set is specially designed to start a 100 HP pump motor.

Camp, Dresser and McKee of Boston, Massachusetts, were the engineers for this unusual application of diesel power.

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WEST SPRINGFIELD, MASSACHUSETTS

PUT ALL THESE FEATURES IN ONE HYDRANT AND YOU HAVE A MATHEWS

A dry-head hydrant; adjustable nozzle levels; replaceable barrel—three of many major features that help make Mathews the one hydrant for sound community protection. The Mathews is designed to be always operable, always dependable, always ready to deliver at full pressure.

STOP NUT PREVENTS STEM FROM BUCKLING. The heavy bronze stop nut halts the downward travel of the stem just before the lower end touches the bottom of the elbow. This prevents any buckling stress on the stem when excessive pressure is put on the opening wrench.

AND ALL THESE OTHER FEATURES, TOO: All working parts contained in replaceable barrel • Head can be faced in any direction • Replaceable head • Any nozzle you specify • Nozzle levels raised or lowered without excavating • Leakproof because stuffing box is cast integral with nozzle section • Operating thread only part requiring lubrication • Protection case of "Sand-Spun" cast iron for strength, toughness, elasticity • Available with bell, mechanical joint or flange pipe connections.

Conform to latest AWWA specifications

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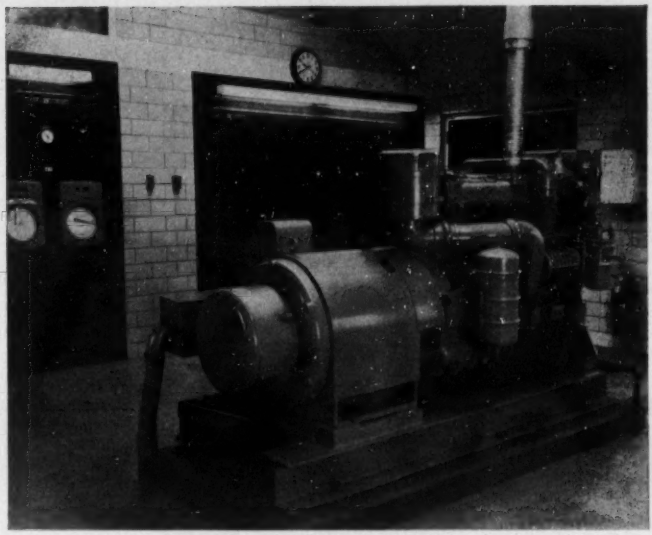
Public Ledger Building, Independence Square, Philadelphia 5, Pa.

Manufacturers also of Mathews Flange Barrel Hydrants, R. D. Wood Hydrants, R. D. Wood Gate Valves, and "Sand-Spun" Pipe (centrifugally cast in sand molds)



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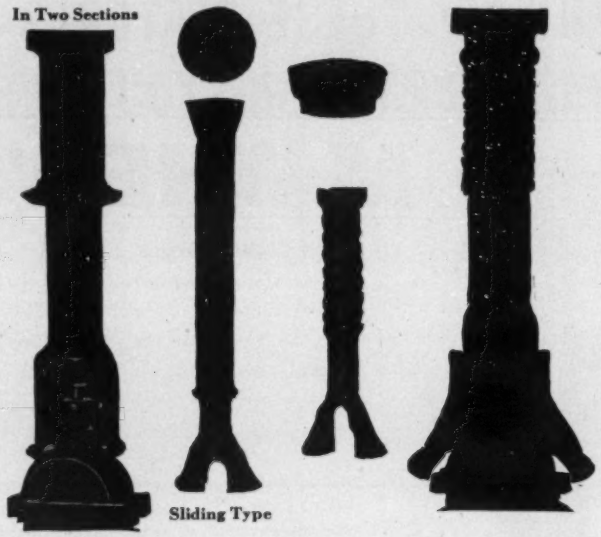

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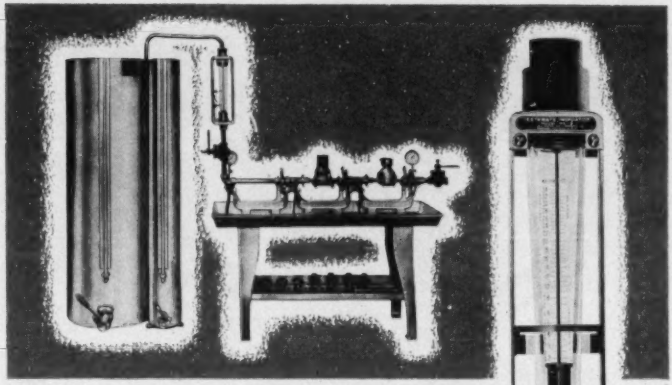

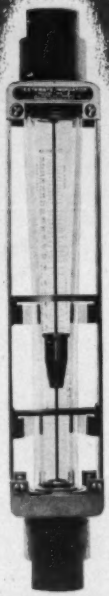

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RATE OF FLOW AT A GLANCE

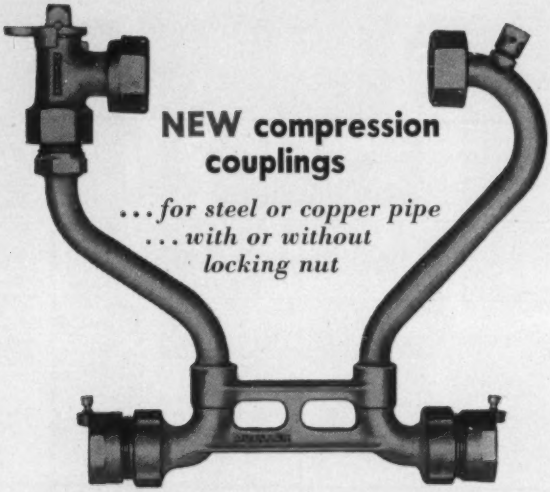
Complete and accurate water meter testing requires definite knowledge of rates of flow. The Ford Testerate Indicator provides quick, precise readings in gallons per minute and is a useful and valuable accessory in any modern meter shop. Accuracy is within 2% down to 1 GPM, and the operator can make corrected readings with rates of flow as small as ¼ GPM.

Easily connected to any meter testing outfit. Write for complete information.

FOR BETTER WATER SERVICES

FORD

THE FORD METER BOX COMPANY, INC. Wabash, Indiana



NEW compression couplings

...for steel or copper pipe
...with or without locking nut

Quickly installed in old piping!

MUELLER® copper meter yokes

You can now install Mueller Copper Meter Yokes in any existing steel or copper piping in just a few minutes and without cutting threads or sweating joints.

Simply cut a short section from the pipe, slip the new Mueller Compression Couplings over the ends of the pipe, position yoke and assemble couplings to it and tighten the compression nuts.

That's all there is to it with Mueller's new Compression Couplings. Permanent, water-tight joints are quickly made even on rough and badly pitted pipe. Possible trouble is avoided because the piping does not have to be moved.

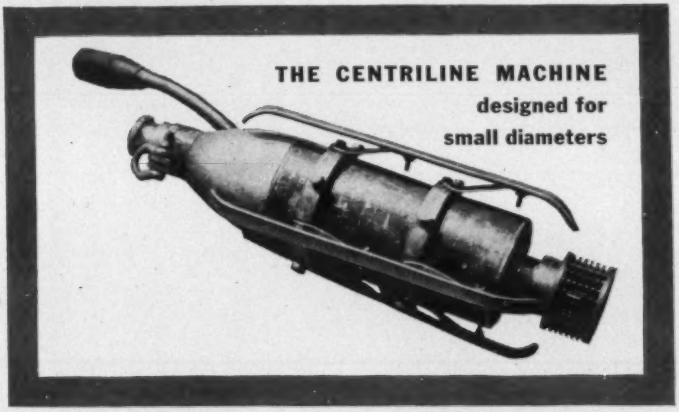
These new, time-saving couplings are now available for all Mueller Copper Meter Yokes with Multi-Purpose Ends. Regular compression nut or locking nut designs can be furnished. The locking nut type positively prevents any movement of the yoke on the pipe and insures continuous electrical bonding of the service piping.

Copper Meter Yokes are just a portion of Mueller's complete line of quality-matched meter setting equipment. Write for complete information and specifications.

MUELLER CO.
DECATUR, ILL.

Factories at: Decatur, Chattanooga, Los Angeles; In Canada: Mueller, Limited, Sarnia, Ontario

NOW! THE CENTRILINE PROCESS is available for 6" to 14" mains, too!



Yes, your city's small but important transmission and distribution lines can also regain their original flow capacity and pressure through the universally accepted Centriline Process of centrifugally applying a cement-mortar coating to the pipe walls. If some of your lines inadequately serve your customers' requirements, including higher demands for fire protection, investigate the numerous advantages of Centrilining your mains now.

The new, small diameter Centriline Machine eliminates most excavations at valves, laterals and corporation cocks. By eliminating these fixed costs, lengthening the distances between access openings and permitting faster lining speeds, the new Centriline Machine has really reduced the cost of lining small mains. So much so, in fact, that every water works operator should reevaluate the economics of small pipe rehabilitation.

Send today for your copy of our illustrated booklet which fully describes how Centriline can help you salvage worn out pipes from 6" to 144" in diameter permanently and for much less than you would imagine.

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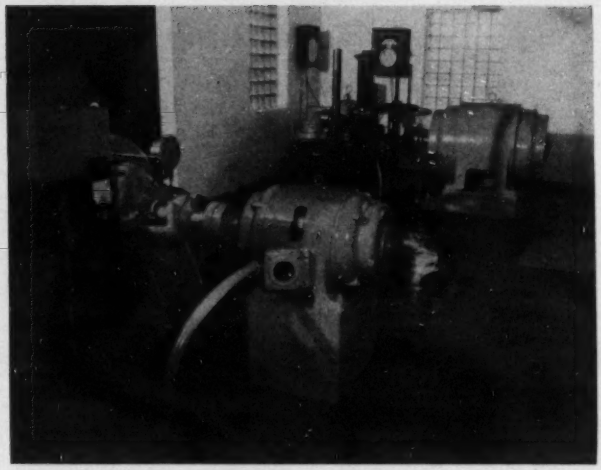
Branch Offices in Principal Cities of the United States, Canada and Latin America.

ANOTHER FAIRBANKS-MORSE LEADER



Marblehead Booster Station
Marblehead, Mass.

Shown in foreground is 15 HP motor driven Fairbanks-Morse 12″ split case centrifugal pump — 3500 GPM at 9′ TDH. Other unit is 100 HP motor driven Fairbanks-Morse 14″ split case centrifugal pump — 5150 GPM at 65′ TDH.

HALEY & WARD, ***Consulting Engineers***
Boston, Mass.

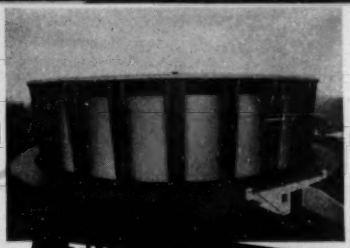
RALPH P. HALL CO., INC., ***Builder***
Stoneham, Mass.

Write or telephone to:

FAIRBANKS, MORSE & CO.

178 Atlantic Avenue **Boston 10, Massachusetts**

Telephone: LAfayette 3-3600



A striking example of fine appearance and exacting craftsmanship is this PDM Steel Reservoir built for the Municipal Authority of the Borough of West View, Pa., in a high-value residential district. An entire hilltop was removed to make room for the 5,000,000 gallon structure, special architectural detailing employed for visual appeal, and a two-tone blue color scheme applied to complete a most unusual and applauded neighborhood feature. • Do you have a particular water storage problem? Let us discuss it with you!

THE CONSTRUCTION QUALITY TELLS YOU it's Pittsburgh-Des Moines

5,000,000 Gallon Reservoir, 150 ft diameter by 40 ft high, built for the Municipal Authority of the Borough of West View, Pa. in Ross Twp., Allegheny County. Structure designed by William Murdoch, Consulting Engineer, Pittsburgh, Pa.

PDM STEEL RESERVOIRS

Pittsburgh-Des Moines Steel Company

Plants at PITTSBURGH, WARREN, BRISTOL, PA. • BALTIMORE • BIRMINGHAM • DES MOINES
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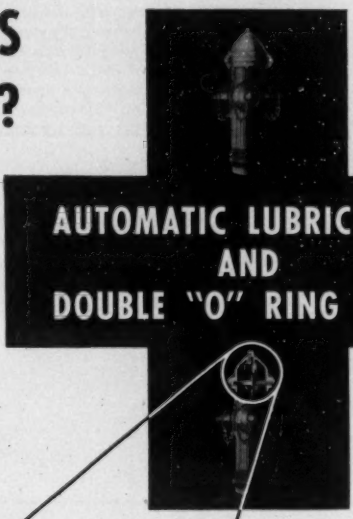
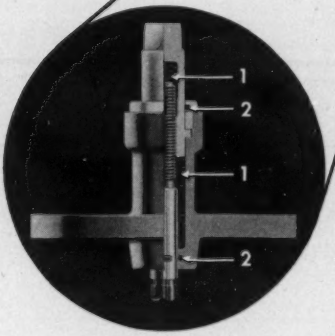
WHAT'S INSIDE? A BIG PLUS



AUTOMATIC LUBRICATION AND DOUBLE "O" RING SEALS



Smith Fire Hydrants are easy to operate, inexpensive to maintain and most dependable in meeting severe climate and operating conditions. In addition to maximum flow and simplicity of design, Smith Hydrants now have two additional features of major importance: (1) Automatic lubrication — chamber sealed with "O" Rings contains a permanent type lubricant — temperature range–30° to 200° F. Each time the hydrant is operated, the threads and bearing surfaces are automatically lubricated. (2) "O" Ring Seals — the lower "O" Ring seals the internal pressure, the upper "O" Ring is a combined external dirt and moisture seal. This construction eliminates the conventional stuffing box and packing gland adjustments.

FIRE HYDRANTS VALVES SINCE 1858
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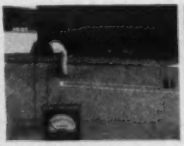
M-Scope "Master" Electronic Witch
Leak Survey Instrument and Pipe Locator

The transistorized "MASTER" Leak Detector—Pipe Finder Combination is the first dual purpose instrument with separate and independent leak detector and pipe finder circuits. Now you can have two instruments in one without any compromise in performance. The "MASTER" Leak Detector—Pipe Finder incorporates the very latest advances in electronic construction and circuitry in addition to having an exceptionally long battery life. An ideal instrument for any Water Department.

Finding a leak under pavement

Locating a leak at the valve



Location of dead ends

Locating a service

Write for information, demonstration or trial.

PIPE LINE EQUIPMENT

JOSEPH G. POLLARD CO., INC.

PIPE LINE EQUIPMENT

PIPE LINE EQUIPMENT

Place your next order with POLLARD

If it's from POLLARD ... It's the Best in Pipe Line Equipment

NEW HYDE PARK • NEW YORK

Branch Offices: 964 Peoples Gas Building, Chicago, Illinois
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Why this "magnetic" meter has no troublesome stuffing box

With Rockwell Sealed Register meters you will never again need to service worn or leaky stuffing boxes—for there are none: A simple, powerful magnetic coupling transmits every motion of the measuring chamber direct to the register without a mechanical coupling or seal.

Stuffing box maintenance is only one way you'll save with these revolutionary meters. You'll gain substantially through a construction in which only two moving parts operate in water—all others run snug, dry and lubricated for life in a hermetically sealed register housing.

Too, the sealed register construction assures that condensation or dirt can never collect underneath the glass to make meter reading difficult. And you can even run this meter under water without harm.

The cost for all this? No more than you pay for ordinary meters—less in fact than for meters fitted with special type registers. Get facts today, write Rockwell Manufacturing Company, Pittsburgh 8, Pa.

POWERFUL MAGNETIC DRIVE

Illustrating how the driver magnet (held in hand) revolves around a watertight compartment at base of register to push the follower magnet, which in turn drives the register shaft.

SEALED REGISTER METERS

another fine product by

ROCKWELL

Warren Foundry & Pipe Division

of

SHAHMOON INDUSTRIES, INC.

Manufacturers of

CAST IRON PIPE & FITTINGS

Made in Accordance with Latest Specifications

Including TYTON Joints

Either Cement Lined or Tar Coated

Pipe Made in Everett — Centrifugally Cast in Sand Lined Molds in 16′ L/L

Pipe Made in Phillipsburg — Centrifugally Cast in Metal Molds in 18′ L/L

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Phillipsburg, N. J.
Ore Mines — Crushed Stone at Dover, N. J.

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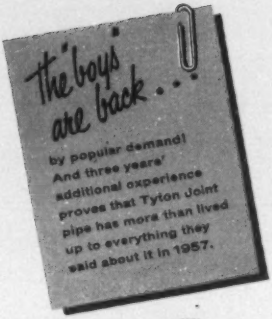
a cinch to


The boys are back . . !
by popular demand!
And three years' additional experience proves that Tyton Joint pipe has more than lived up to everything they said about it in 1957.

Tyton Joint® pipe is *almost* as easy to install as our hillbilly friend indicates. Only one accessory needed . . . a specially designed rubber gasket that fits into the bell of the receiving pipe. A push or two and the connecting pipe compresses the gasket . . . seals the joint bottle-tight and permanently.

No bell holes. No waiting for weather. Tyton Joint pipe can be laid in rain or wet trench. It's so simple, in fact, even an inexperienced crew quickly becomes expert.

U.S. cast iron **PIPE** FOR WATER, SEWERAGE AND

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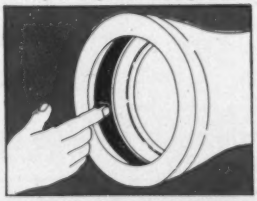
A WHOLLY INTEGRATED PRODUCER FROM MINES AND BLAST FURNACES TO FINISHED PIPE

INDUSTRIAL SERVICE CAST IRON

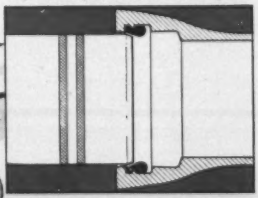
TYTON JOINT

ONLY FOUR SIMPLE ACTIONS

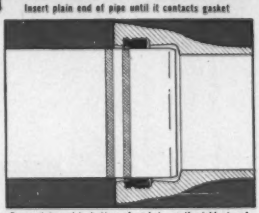
Insert gasket with groove over bead in gasket seat



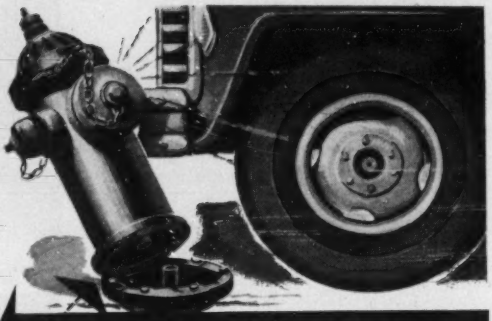
Wipe a film of special lubricant over inside of gasket



Insert plain end of pipe until it contacts gasket



Force plain end to bottom of socket . . . the job's done!



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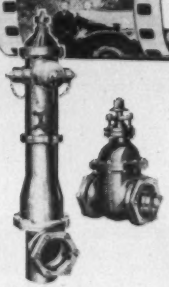

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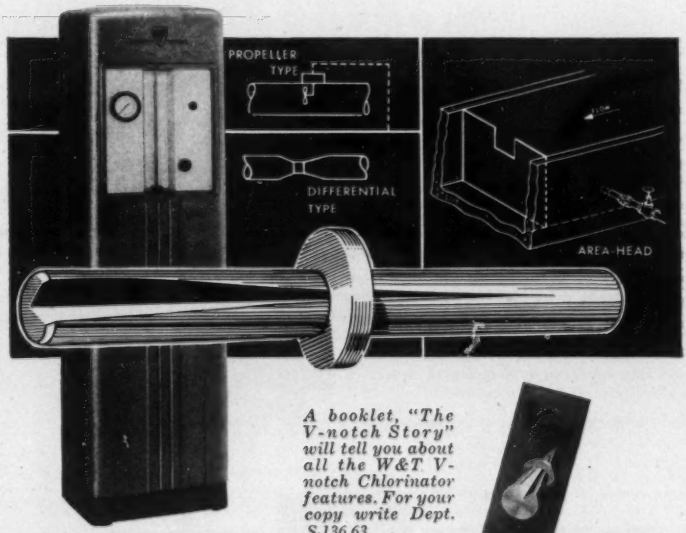

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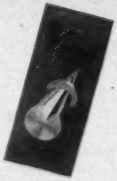

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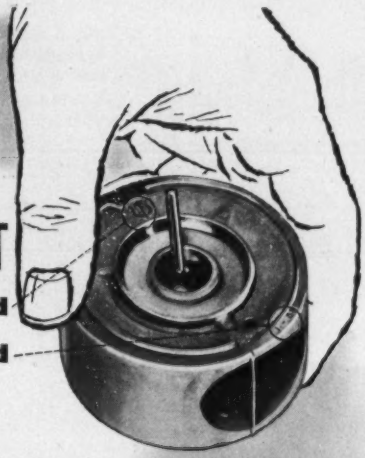

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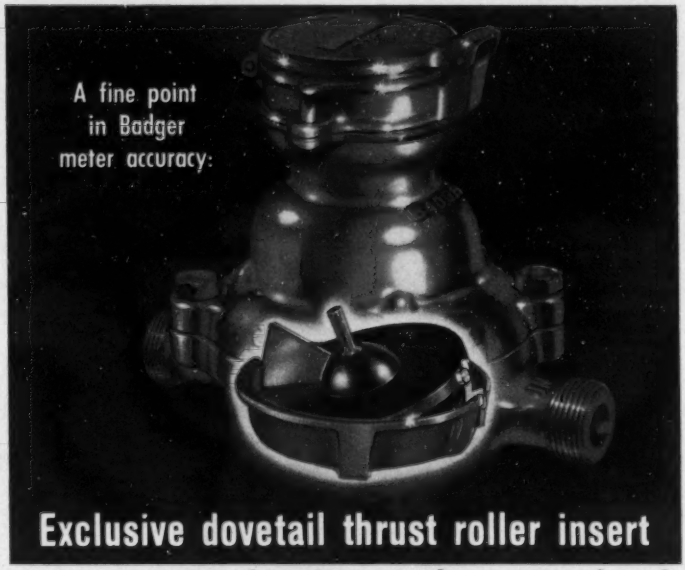

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John Haley

WARREN A. GENTNER

President of the New England Water Works Association—
1959-1960

NEW ENGLAND WATER WORKS ASSOCIATION
ORGANIZED 1882

VOL. LXXIX MARCH, 1960 NO. 1

This Association, as a body, is not responsible for the statements or opinions of any individual.

MODERN TRENDS IN SEA-WATER CONVERSION

BY JOHN J. CAMPOBASSO*

[*Read March 19, 1959.*]

It may seem strange and untimely to most of this audience that a paper on Sea-Water Conversion be presented to the New England Water Works Association, especially so at this recurring flood season, when our local problem seems to be one of the proper control, storage and distribution of our over-abundant supply of fresh water. Fresh water supplies are not so plentiful in other areas of the world. A glance at world maps reveals that a large portion of the arid lands and a great percentage of the earth's urban population are located within 100 miles of the sea. In this country, we have 22 coastal states that contain approximately 65% of our industry and 55% of our population. Yet some of these areas are faced with drastic fresh-water shortages. It seems, therefore, that the earth's population could more likely be limited by its water supply than by its food supply. Since the solution of this problem, in its broader aspects, is a major challenge to engineers and water-works men everywhere, it becomes of especial interest in this area with its concentration of engineering and technical skills.

The oceans of the earth contain approximately 500,000,000 cubic miles of water. The two main reasons why this vast reservoir has not been more widely used as a source of fresh water have been the lack of economic incentive and the inherent technical problem of separating those components of a salt-water solution that have a great affinity for the solution. As man's activities extend and expand into areas where sea water is the only available source of water the need for an economical sea-water conversion process becomes acute. There are now over twenty countries of the world participating in active research

*Manager, Evaporator Division, Badger Manufacturing Co., 230 Bent St., Cambridge 41, Mass.

work in the sea-water conversion field. Many processes and phenomena are under investigation by these engineering and research organizations, some of the most important of which are outlined in Table 1.

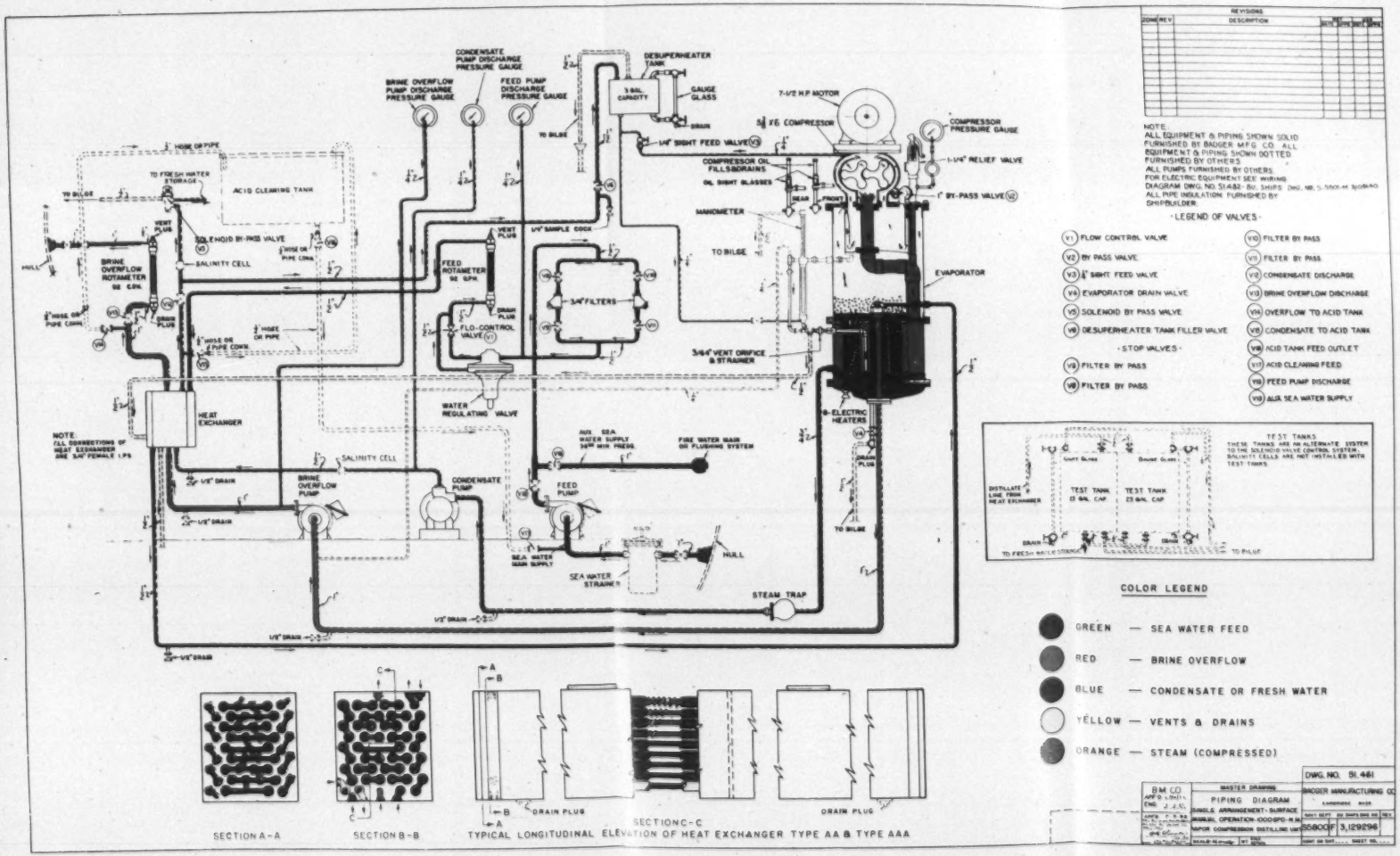
Progress is being reported all along the line with Distillation, Freezing and Electrodialysis leading the way. As evidenced by the number of large sea-water plants presently in operation, all employing some form of distillation, it appears that process has made the most significant advance. Distilling plants having a total capacity of 5 mgd are now in operation in Kuwait on the Persian Gulf. Distilling plants with an output of 3 mgd have been installed at Aruba. All major ships of the U. S. Navy have distilling plants with capacities ranging from 1 to 4 thousand gallons per day on submarines and up to 200,000 gallons per day on the Forrestal Class aircraft carriers.

Time will not permit a detailed examination and discussion of all processes known to be promising. I should like to go into some detail on two of the distillation methods that we have been working with for the past 19 years, namely the vapor compression and the flash type.

The distillation process applied to converting sea water to potable water consists of evaporating a part of the sea water and condensation of the salt-free vapor. The products from this process are pure water, called the distillate, and concentrated salt solution, or residue. In this process the water is removed from the salts rather than salts from water.

The vapor-compression plant, by utilizing the "heat pump" principle of recycling the latent heat of evaporation, eliminates the use of direct-fired equipment, as well as the need for large volumes of condensing water required by other types of distilling plants. This type also shows a startling fuel economy when compared with single- and multiple-effect evaporators.

The heat cycle involved is illustrated in the flow diagram shown in Figure 1. The vapor-compression distiller consists of four main pieces of equipment: (1) power unit, (2) a vapor compressor, (3) an evaporator and (4) heat exchangers. When the sea water inside the tubes of the evaporator reaches its boiling point, the vapor produced passes to the compressor, where it is compressed and its "heat gradient" raised sufficiently to



ZONE	REV	DESCRIPTION	BY	CHK'D	APP'D	DATE

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LEGEND OF VALVES

V1 FLOW CONTROL VALVE	V10 FILTER BY PASS
V2 BY PASS VALVE	V11 FILTER BY PASS
V3 1/4" SIGHT FEED VALVE	V12 CONDENSATE DISCHARGE
V4 EVAPORATOR DRAIN VALVE	V13 BRINE OVERFLOW DISCHARGE
V5 SOLENOID BY PASS VALVE	V14 OVERFLOW TO ACID TANK
V6 DESUPERHEATER TANK FILLER VALVE	V15 CONDENSATE TO ACID TANK
STOP VALVES	V16 ACID TANK FEED OUTLET
V7 FILTER BY PASS	V17 ACID CLEANING FEED
V8 FILTER BY PASS	V18 FEED PUMP DISCHARGE
	V19 AUX. SEA WATER SUPPLY

TEST TANKS
THESE TANKS ARE AN ALTERNATE SYSTEM TO THE SOLENOID VALVE CONTROL SYSTEM. SALINITY CELLS ARE NOT INSTALLED WITH TEST TANKS.
SIGHT GLASS
GAUGE GLASS
DISTILLATE LINE FROM HEAT EXCHANGER
TEST TANK 25 GAL. CAP.
TEST TANK 25 GAL. CAP.
DRAIN
TO FRESH WATER STORAGE
TO BILGE

COLOR LEGEND

- GREEN — SEA WATER FEED
- RED — BRINE OVERFLOW
- BLUE — CONDENSATE OR FRESH WATER
- YELLOW — VENTS & DRAINS
- ORANGE — STEAM (COMPRESSED)

BM CO. APP'D	MASTER DRAWING	DWG. NO. 51-481
CHK'D	PIPING DIAGRAM	BADGER MANUFACTURING CO.
ENG.	SINGLE ARRANGEMENT - SURFACE	CAMBRIDGE MASS.
DATE	MANUAL OPERATION - 1000 GPD - H.W.	SHIP'S SCHEM. NO.
	VAPOR COMPRESSION DISTILLING UNIT	3580CF 3,129296
	SCALE	SHEET NO.

FIG. 1.

TABLE 1.—POTENTIAL SEPARATION PROCESSES AND PHENOMENA

I *Physical Processes and Phenomena*

A. *Vaporization*
1. Vapor-compression distillation
2. Single and multiple-effect evaporation
3. Flash evaporation
4. Flash-type multiple-effect evaporation
5. Combination compression distillation and multiple-effect evaporation
6. Critical pressure devices
7. Superheated steam
8. Underwater combustion
9. Temperature differences

B. *Crystallization*
1. Freezing of water
2. Crystallization of salts

C. *Sublimation*

D. *Adsorption*
1. Adsorption of water
2. Adsorption of ions

E. *Diffusion effects*
1. Thermal diffusion
2. Gravitational diffusion

F. *Ultrasonics*

I′ *Physical Processes and Phenomena (Continued)*

G. *Osmosis*
1. Molecular oil films
2. Biological membranes

H. *Immiscible liquids*

II *Chemical Processes and Phenomena*

A. *Ion-exchange*
B. *Hydration*
C. *Precipitation*

III *Electrical Processes and Phenomena*

A. *Electro-ion-migration*
1. Electrolysis—2- and 3-compartment cells
2. Perm-selective membranes
3. Electro-gravitational methods

B. *Streaming potential*

C. *Electrostatic effects*
1. Migration in electrostatic field
2. Dielectric effects

D. *Electromagnetic effects*
1. Migration in electromagnetic field
2. Magnetic susceptibility

E. *Ultra-high-frequency currents*

allow it to flow back to the same evaporator, this time on the condensing surfaces (outside of the tubes). Thus every pound of steam produced by the evaporator is returned as the heating medium for the same evaporator. This steam is condensed and withdrawn as distillate.

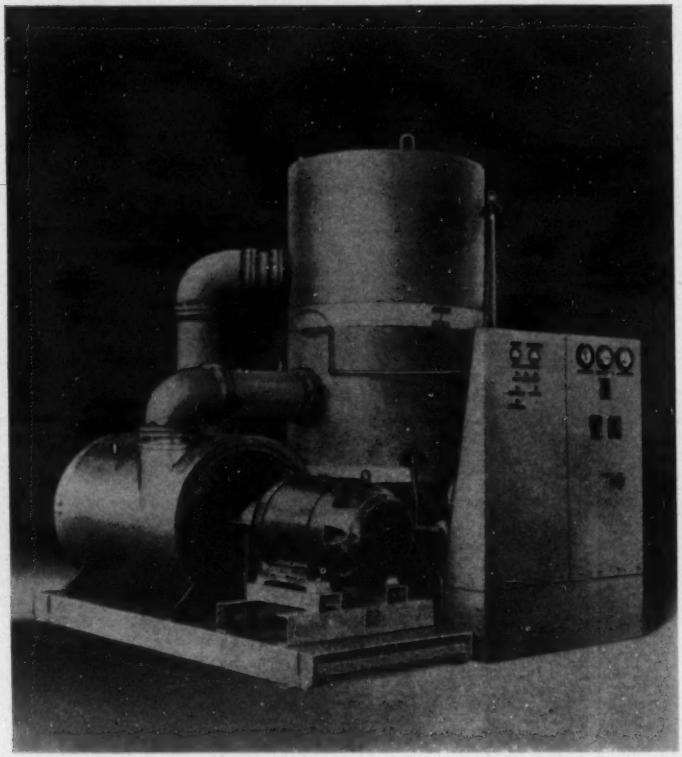


FIG. 2—VAPOR-COMPRESSION DISTILLING UNIT, ELECTRIC-DRIVEN, 400 GALLONS PER HOUR (Badger Manufacturing Co.)

The distillate is pumped through a system of heat exchangers where is helps heat up the incoming cold sea-water feed. The residue or concentrated brine is continuously drawn off and also passes through heat exchangers, adding more heat to the sea-water feed.

Thousands of standard vapor-compression units are in use today, both on shipboard and in land-based installations. Figures 2 and 3 show two typical, vapor-compression, sea-water distilling plants.

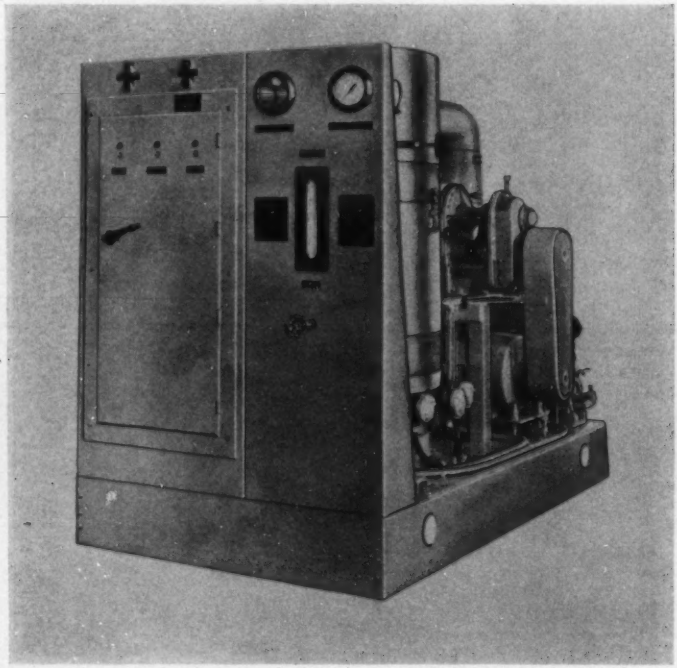


FIG. 3—VAPOR-COMPRESSION DISTILLING UNIT, ELECTRIC-DRIVEN, 100 GALLONS PER HOUR, MODEL SUY-2 (Badger Manufacturing Co.)

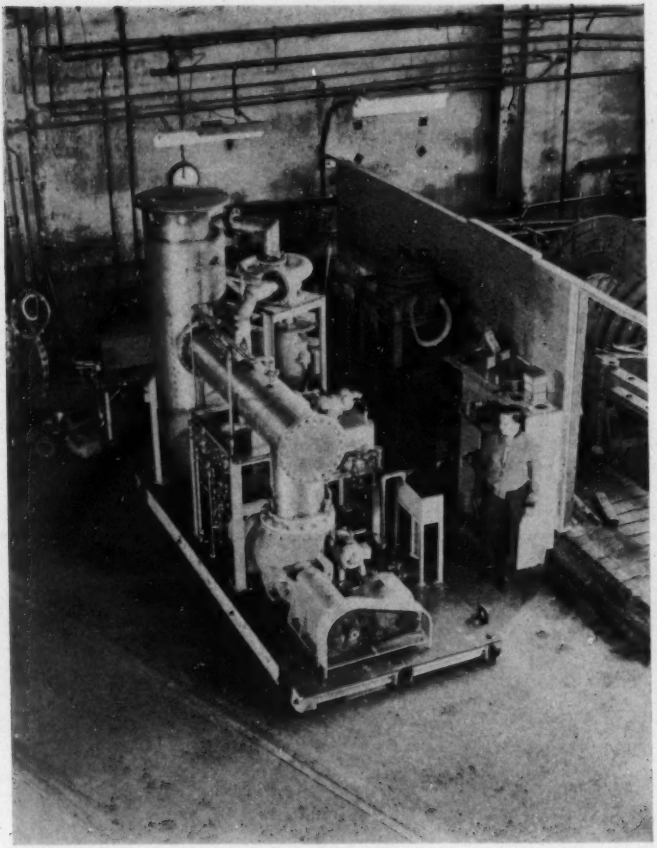


FIG. 4—RECIRCULATION PLANT

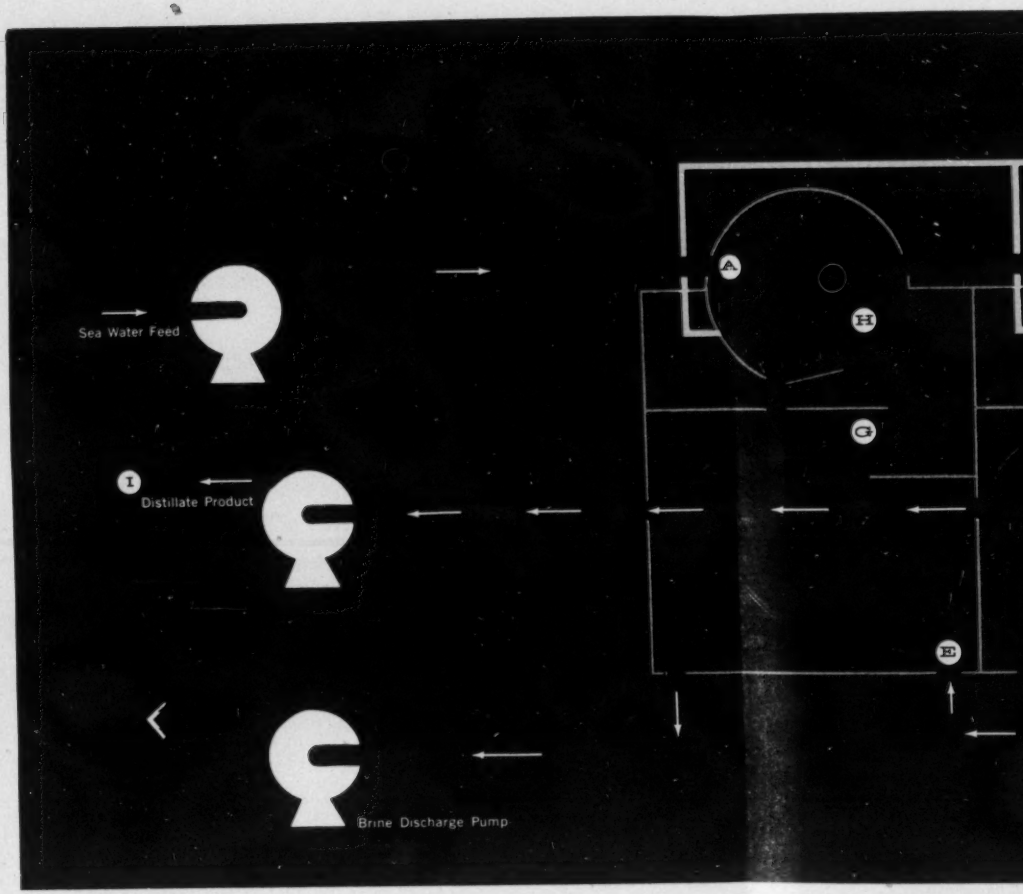
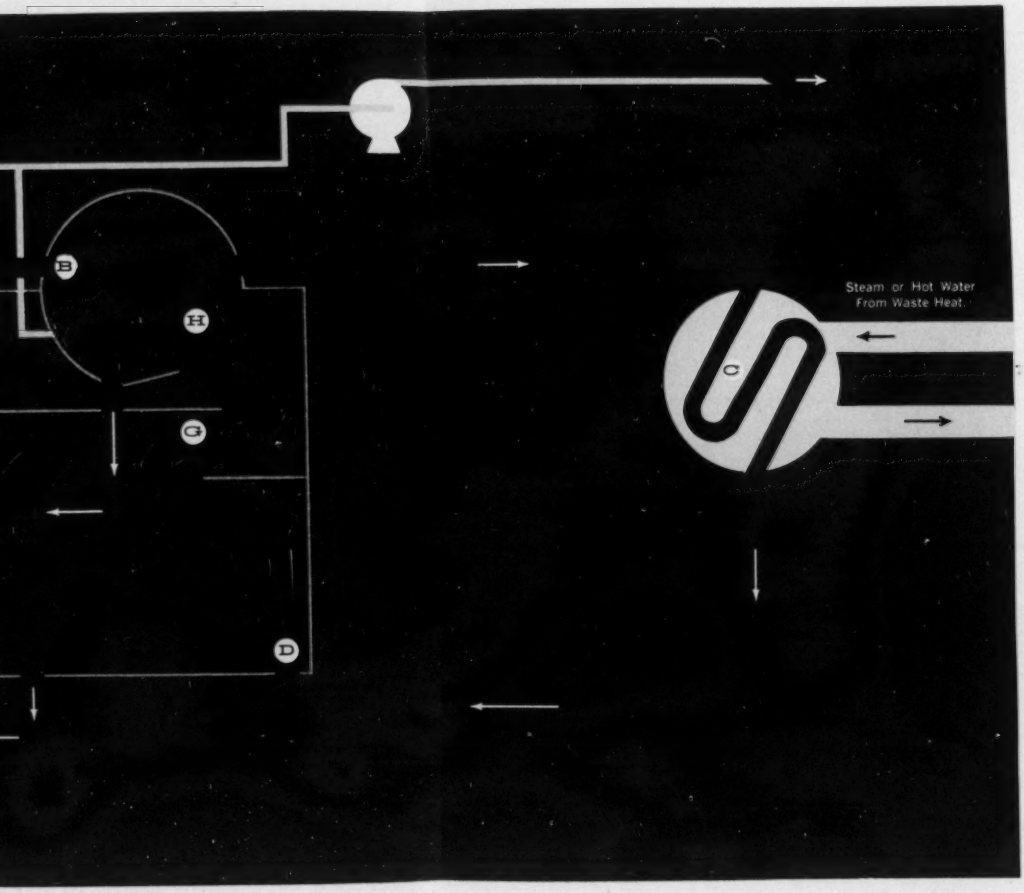


FIG. 5—BADGER FLASH EVAP



VAPORATOR (PATENTS APPLIED FOR)

As is true with all types of evaporating equipment, scale forms on the heating surfaces and must be removed or prevented. With sea water boiling at atmospheric pressure, the scale formed is mostly magnesium hydroxide, and this is readily removed by recirculating an acid solution through the equipment at regular intervals.

Several important studies are currently under way, aimed at developing operating techniques which will retard or prevent scale formation. These are (1) low-temperature operation, (2) forced recirculation of brine, (3) pH control and (4) rotating-disc-(Hickman) type evaporators. These methods of scale control, while not perfected at present, are nonetheless sufficiently developed to be in use either singly or in combination, and the results indicate that scale-free operation is not an impossibility.

A recent development, aimed at achieving greater fuel economy and scale-free operation, is the forced-recirculation-type vapor-compression plant. In this type the evaporation takes place under partial vacuum and at a temperature of approximately 150° F. The concentrated brine is recirculated through the tubes of a reboiler at velocities of 10-15 ft per sec. The liquid in the tubes is suppressed so that no boiling takes place in them. The evaporation takes place in a flash chamber. The rest of the apparatus is typical, as seen in Fig. 4, showing a 4,000-gpd pilot plant under test.

Another important distilling plant widely used today is the multi-stage flash type. While the principle is not new, the application to the converting of sea water in several stages and at low temperatures is a recent development. As illustrated in Fig. 5, the flash plant works on a temperature-difference principle.

This type of distilling plant consists of a multi-stage flash-type evaporator, complete with flash chambers (D and E), vapor separators (G), stage condensers (H), liquid pumps, vacuum pumps, heat exchangers (C), interconnecting piping, and control instruments and gauges.

This distilling plant is of the once-through, regenerative-cycle type. The flow through the plant is as follows:

For simplification a two-stage plant is illustrated. Four,

five and six-stage units use identical flow and principle of operation.

Cold sea water is introduced into the second-stage condenser (A) and then passes to the first-stage condenser (B) in series. The cold sea water is thus partially heated and then flows to the sea-water heat exchanger, where it is further heated to the desired temperature (about 175° F). The heat source can be low-pressure steam, waste heat from engine jackets, or any other available source of heat.

The heated sea water is now returned to the distiller first-stage flash chamber (D). A portion of the heated sea water is flashed in vapor, under partial vacuum. The remainder passes to the second-stage flash chamber (E), where still more is flashed into vapor. In like manner the remainder could be passed on into the 3rd- and 4th-stage flash chambers, etc., for successive flashing. The unflashed residue is pumped from the last stage to waste.

The vapor formed in each stage passes up through vapor separators, where any liquid entrainment is removed. The vapor then flows to the stage condensers, where it is condensed to form the condensate (fresh water). The condensate or fresh water is then pumped to storage tanks. The whole system is kept under partial vacuum with use of a mechanical vacuum pump or steam-ejector type.

Thus we have seen how the vapor-compression plant operates at the higher-temperature end of a given heat cycle, while the flash plant is more suited for the low-temperature end. The next step then is to use both types in series combination, as shown in Fig. 6, illustrating the flow through a proposed 1-mgd plant.

It is my prediction that sea-water conversion plants of this type, having an output of a million gallons per day or more, will be in operation in this country with the next few years.

This leads to the next and most important problem: the question of cost. What will potable water produced from sea water cost? I want to make it clear at this time that any cost figures given here are production costs only that is, the actual cost of converted sea water at the fresh-water outlet of the plant. These figures *do not* include distribution costs. They

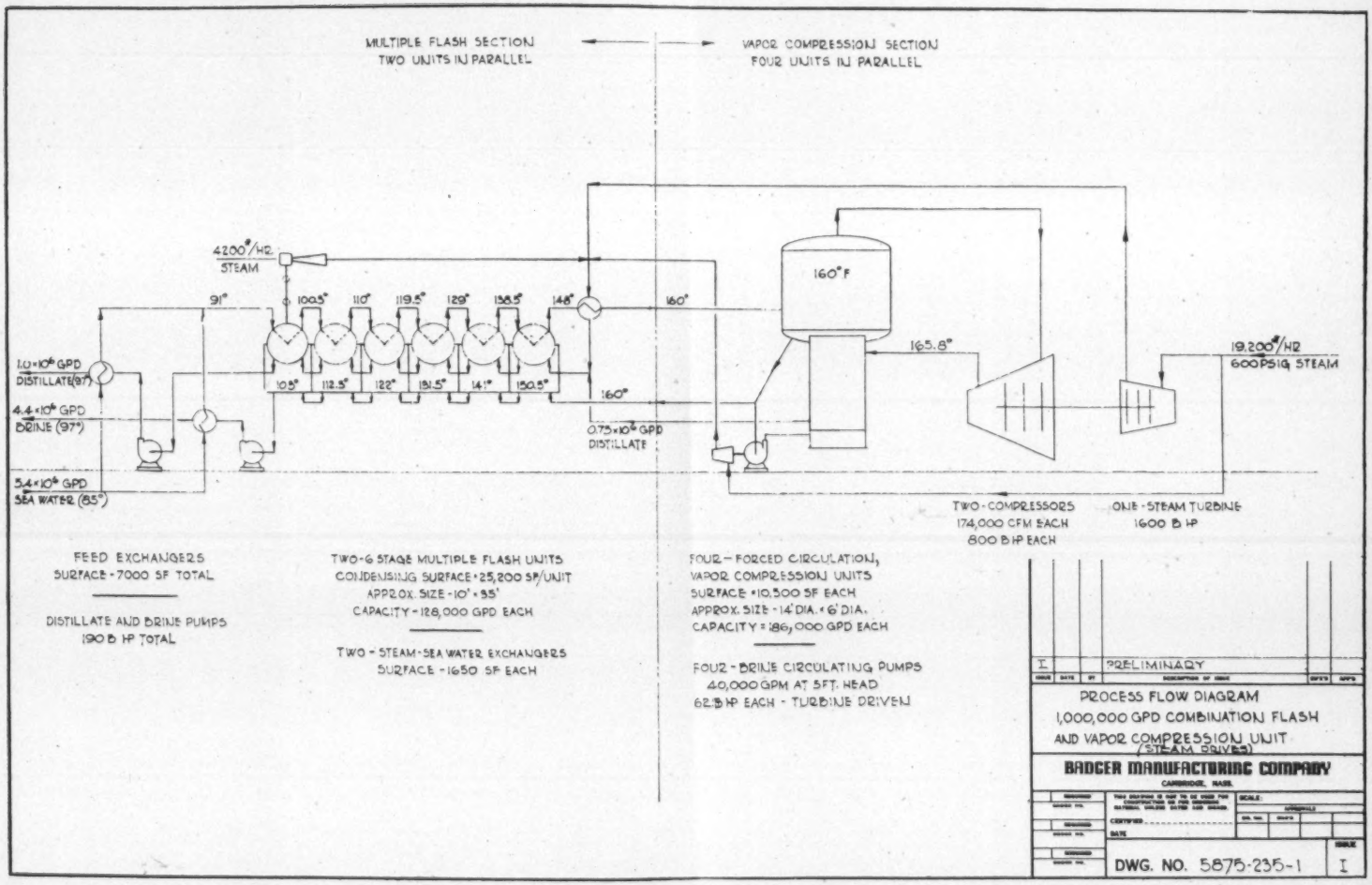

MULTIPLE FLASH SECTION
TWO UNITS IN PARALLEL
VAPOR COMPRESSION SECTION
FOUR UNITS IN PARALLEL
4200#/HR.
STEAM
91°
100.5°
110°
119.5°
129°
138.5°
148°
160°
160°F
165.8°
19,200#/HR
600 PSIG STEAM
1.0×10⁶ GPD
DISTILLATE (97°)
4.4×10⁶ GPD
BRINE (97°)
5.4×10⁶ GPD
SEA WATER (85°)
105°
112.5°
122°
131.5°
141°
150.5°
160°
0.75×10⁶ GPD
DISTILLATE
TWO - COMPRESSORS
174,000 CFM EACH
800 B HP EACH
ONE - STEAM TURBINE
1600 B HP
FEED EXCHANGERS
SURFACE - 7000 SF TOTAL
DISTILLATE AND BRINE PUMPS
190 B HP TOTAL
TWO-6 STAGE MULTIPLE FLASH UNITS
CONDENSING SURFACE = 25,200 SF/UNIT
APPROX. SIZE - 10' × 35'
CAPACITY - 128,000 GPD EACH
TWO - STEAM - SEA WATER EXCHANGERS
SURFACE - 1650 SF EACH
FOUR - FORCED CIRCULATION,
VAPOR COMPRESSION UNITS
SURFACE = 10,500 SF EACH
APPROX. SIZE - 14' DIA. × 6' DIA.
CAPACITY = 186,000 GPD EACH
FOUR - BRINE CIRCULATING PUMPS
40,000 GPM AT 5FT. HEAD
625 HP EACH - TURBINE DRIVEN
I
PRELIMINARY
PROCESS FLOW DIAGRAM
1,000,000 GPD COMBINATION FLASH
AND VAPOR COMPRESSION UNIT
(STEAM DRIVEN)
BADGER MANUFACTURING COMPANY
CAMBRIDGE, MASS.
DWG. NO. 5875-235-1
I

FIG. 6

do include amortization of the initial costs of the conversion plant, operating labor, fuel, and maintenance and supplies.

There have been many press releases recently, quoting estimated costs at anywhere from $5.00 per 1,000 gal down to as low as 20 cents per 1,000 gal. I am sure that everyone familiar with the selling price of water in our local communities must readily recognize that a cost of 20 cents per 1,000 gal (approximately 16 cents per 100 cu ft) is unrealistic.

Our experience with vapor-compression distilling plants shows costs of production as set forth on Fig. 7.

As the individual conversion plants grow larger and are used in combination, as discussed earlier, we can see what can happen to this curve. Most authorities now agree that 50 cents per 1,000 gal should be our goal. If I am permitted another prediction, I feel that this can be achieved in the next decade.

This may not be competitive in price with fresh-water supplies in many areas today. On the other hand, 50 cents or even $5.00 per thousand gallons is not unreasonable at the right time and place, if we bear in mind the words of Benjamin Franklin, who said, "When the well is dry, we know the worth of water."

The roster of private and public organizations engaged in sea-water-conversion research and development includes many leading industrial concerns, educational institutions, Federal and State government agencies, and private research companies.

Of especial note at this time is the program under way in the Office of Saline Water of the U. S. Department of Interior. This organization is in the middle of a most comprehensive research program, covering most sea-water and brackish-water conversion processes. The last Congress authorized an extensive demonstration-plant program, to complement the present research and development program. The demonstration-plant program is intended to test several of the conversion processes that have shown the most promise. Five such plants have been authorized, three for sea water and two for brackish water. Two of the sea-water plants are to have an output of not less than 1 mgd each. One of the two brackish-water plants will have a capacity of not less than 250,000 gpd. The sea-water plants are to be located on the West Coast, Gulf Coast and East Coast,

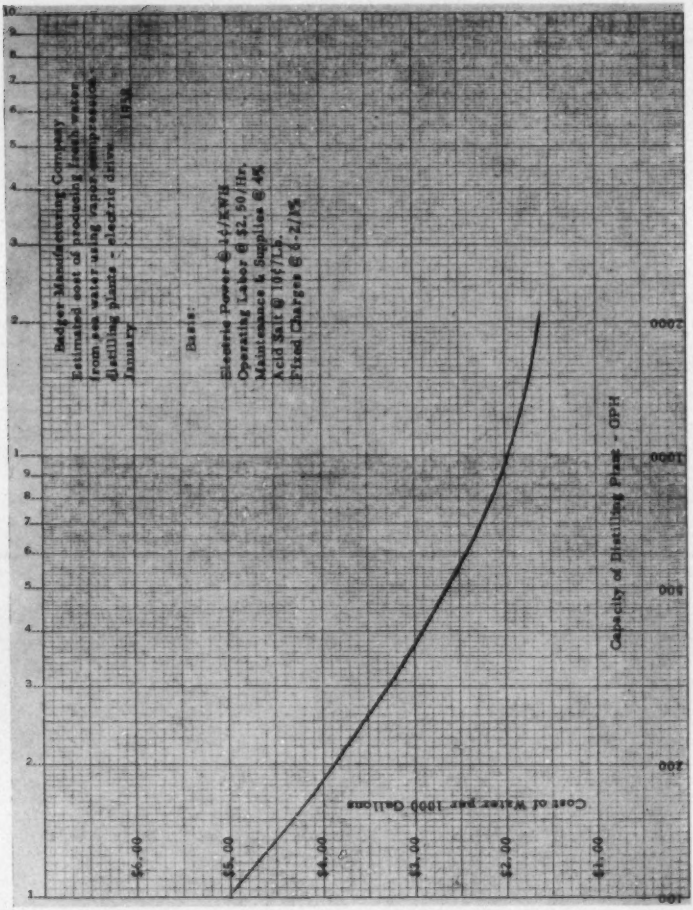

Badger Manufacturing Company
Estimated cost of producing fresh water from sea water using vapor compression distilling plants - electric drive.
January 1953
Basis:
Electric Power @ 1¢/KWH
Operating Labor @ $2.50/Hr.
Maintenance & Supplies @ 4%
Acid Salt @ 10¢/Lb.
Fixed Charges @ 6-2/3%
Cost of Water per 1000 Gallons
Capacity of Distilling Plant - GPH
$6.00
$5.00
$4.00
$3.00
$2.00
$1.00
100
200
500
1000
2000

FIG. 7

while one brackish-water plant is scheduled to be located in the Southwest and the other to be located in the Northern Great Plains. Engineering work on the first sea-water plant is expected to start possibly in 1960.

A HISTORY OF THE PROVIDENCE WATER WORKS AND ITS TREATMENT METHODS

BY JOHN J. COLLINS*

[*Read April 16, 1959.*]

The early residents of Providence obtained their water supply from wells and springs; although, prior to the introduction of the Pawtuxet River supply at Pettaconsett in 1871 there were several small community supplies, some of which had been in use for many years. Reminders of these early water works, in the form of wooden pipes, are still found occasionally in street excavations.

Construction of the Pawtuxet River supply at Pettaconsett was started in the spring of 1870, and the first service pipe was opened on December 1, 1871. Prior to 1906 water was taken directly from the river without any purification whatsoever, and the old distribution reservoirs were of the open type. Slow sand filtration was adopted in 1906, followed by chlorination in 1917 and treatment with lime in 1920.

With the growth of Providence and the extension of the system in nearby communities, the consumption during extremely dry weather exceeded the natural flow of the river, and the deficiency was made up from water stored in reservoirs owned and controlled by mills farther up the river. Moreover, from a sanitary standpoint, the quality of the river water was becoming seriously impaired as a result of the river's passing through a dozen mill villages, containing 18 mills and a population of more than 30,000 and no provisions for treating human or mill wastes.

The menace of a possible shortage of water led to the appointment by the City Council in January, 1913, of a committee to investigate the possibility of developing an increased water supply. As a result of this committee's work, legislation was enacted under which the Scituate supply was built. Water from this supply was delivered into the system for the first time on September 30, 1926. The entire project was completed in 1929 at a cost of $21,000,000.

*Superintendent of Filtration, Water Supply Board, Providence, R. I.

The supply is derived from a watershed of 92.8 sq mi on the north branch of the Pawtuxet River. Surface water from the watershed is eventually collected in our main reservoir, known as Scituate Reservoir, and five small reservoirs, all tributary to the main body. The available capacity of the Scituate Reservoir, 36,611 mil gal, together with the 3,135-mil gal available capacity of the five small reservoirs, provides a total of 39,746 mil gal.

Water flows by gravity from the gate house at Gainer Memorial Dam through two 60-inch steel pipes and a section of concrete pipe 90 in. in diameter to the influent chamber at the Purification Works. From the beginning of operations in 1926 through August 8, 1931, treatment consisted of influent aeration, provided by the gravity head of water in the reservoir, followed by addition of alum, mixing in a tangential mixer 35 ft in diameter and 30 ft deep, flow through two series-operated coagulation and sedimentation basins, rapid sand filtration, effluent aeration, and treatment with hydrated lime prior to entering the gravity aqueduct, leading to the distribution system.

The ten filters each contained a 30-inch depth of sand, having an effective size of 0.37 mm and a uniformity coefficient of 1.46, supported by 18 in. of gravel, ranging in size from 2 in. down to 1/12 inch. They were operated at 4.4 mgd each, equivalent to a rate of 1.76 gal per min per sq ft, and were washed when the loss of head reached approximately 7 ft.

During the years of alum treatment there were marked variations in the characteristics of the plant effluent; pH varied from 5.9 to 10.2, color from 0 to 30 ppm, iron from 0.00 to 2.00 ppm, and manganese from 0.03 to 0.35 ppm. Because of numerous complaints, due to precipitation of iron and manganese in the distribution system, a change to copperas-lime treatment was made on August 9, 1931. This was later modified by chlorination of the copperas, to provide a ferric iron coagulant. Chlorinated copperas and lime was replaced by ferric sulphate and lime from June 23, 1933, to July 26, 1936, followed by liquid ferric chloride and lime from July 27, 1936, to July 24, 1946. A return to the ferric sulphate-lime treatment was made on July 25, 1946, and this treatment has remained in effect since that time.

Since the adoption of iron-lime treatment the coagulant has

been added prior to influent aeration, the lime being added after aeration and before mixing. Coagulation has been carried out at a pH of 9.5 to 10.3 and has resulted in the production of a very stable effluent water. Since use of a manufactured ferric iron coagulant began on June 23, 1933, the effluent color has varied from 2 to 15 ppm with an average of 6. Iron has ranged between 0.00 and 0.25 ppm with an average of 0.01, and manganese from 0.00 to 0.08 ppm with an average of 0.00. The tap-water color has varied from 2 to 15 ppm with an average of 6, while the iron content has ranged between 0.00 and 0.30 ppm, with an average of 0.02. Manganese has been between 0.00 and 0.10 ppm with an average of 0.00. The striking similarity of effluent and tap-water characteristics, together with the removal of iron and manganese, has proved the efficiency of the ferric iron and lime treatment for this supply.

Out of abundant caution, chlorination of the effluent water has been practiced continuously since December, 1941. Prior to that time chlorine treatment was used for the most part for experimental purposes or during times of construction.

In the original design of the Purification Works, the site selected for the location of the coagulation basins was formerly marsh land. The slopes of these two huge basins were heavily riprapped as a protection against wave action. As a result of our treatment process, several thousand cubic feet of sludge were deposited annually in the bottom of the basins. In order to remove this material, the basins had to be taken out of service and completely drained, after which the labor crews would attempt to remove the sludge with hose lines and brooms. This cleaning process was never complete or satisfactory. Sludge would deposit in mud pockets and between the riprap, forming a natural cyst for bacterial growth. On numerous occasions the raw water entering the plant would contain a 20° C bacteria count of only 35 per cc, but after passing through the basins it would increase to 3,000 per cc.

Between 1938 and 1940, under a grant from the Public Works Administration, extensions and improvements were completed at the Purification Works. Work performed under this program consisted of lining the slopes and bottoms of the basins with a concrete mat, with facilities for removing the sludge

deposits through a series of drain channels. Additional work included the installation of four new filters, electrification of all valves and filter-control mechanism, a central control board for operating the entire plant, a pneumatic materials-handling system, new lime feeders and slakers, and new chlorinating equipment.

The concrete-lined basins eliminated the previous undesirable conditions and have enabled us to perform cleaning operations rapidly and completely. When our schedule calls for cleaning a basin, the motor-operated drain gates are opened from push-button stations, located on the central control board. After the basin has been drained of water and a large amount of the sludge, jeeps equipped with wooden plows are used to push the remaining sludge from the flat sections of the bottom into troughs, leading to the drain chamber. Water under high pressure from hydrants located around the periphery of the basin is used to flush the slopes and bottom completely clean.

The four additional filters proved to be a real asset to the plant, as the peak demands on the system for four years prior to their installation required the operation of all ten filters, with no spare capacity whatsoever. During the dry summer months of 1939 the maximum demand on numerous occasions exceeded the entire plant output, forcing us to depend on reduced load requirements over the weekend, to establish normal operating levels in our distribution reservoirs. The new units, similar in design to the original ten, increased the operating capacity of the plant from 44 to 61.6 mgd.

Complete electrical operation of the Purification Plant has provided greater dependability and efficiency than existed under the former hydraulic operation. A 17-section control board centralizes the operation of the entire plant. The board is located in the effluent gallery and replaced numerous individual hydraulic tables, formerly located in the filter and effluent galleries.

The entire cost of completing these extensions and improvements between 1938 and 1940 totalled $1,131,000. The Public Works Administration contributed $509,000, which left a direct cost to the Water Department of $622,000.

Insufficient bin storage for treatment chemicals had been

a problem from shortly after the start of plant operations in 1926 and had grown progressively worse as demands on the treatment works increased. Two separate storage silos for ferric sulphate and quicklime were constructed to remedy this situation. They were completed and placed in operation in 1950. Each silo is of glazed segment tile masonry and has an inside diameter of 16 ft, a height of 55 ft and a capacity for 180 tons of material; which, in addition to the storage provided in feeding hoppers in the Purification Works Head House, assures a maximum of more than 100 average days' supply. Handling of the chemicals, from railroad cars to a special truck, and then to the silos and feeding hoppers is done pneumatically.

This increased storage has permitted us to absorb delays in shipment occasioned by manufacturing shutdowns, strikes, rail embargoes, etc., and has provided a means whereby we can refuse acceptance of material not meeting the specification requirements.

On November 2, 1950, resolutions were presented to the City Council, providing for fluoridation of the water supply. After numerous conferences with officials and health department officers of cities and towns served by the supply, officials and representatives of the Rhode Island Medical Society, the Providence District Dental Society, and the State Division of Sanitary Engineering, and others, the Public Welfare Committee on July 5, 1951, recommended to the City Council the adoption of the resolutions, and the Council took favorable action. This resolution, number 552, was approved on July 9, 1951. Subsequently, the cities of Cranston and Warwick and the towns of North Providence, Johnston and Smithfield approved fluoridation by August 20, 1951.

After numerous investigations were made as to the proper and recognized safe methods for handling and feeding fluoride compounds, five separate contracts were awarded covering a Fluoridizer, pneumatic conveying system, piping, electrical work, and fork-lift truck. The installation of the feeding and conveying equipment was done by the department's maintenance force, and the total amount of contracts awarded for equipment was $20,000.

On August 14, 1952, a test run of the completed installation

was made in the presence of the President of the Rhode Island Dental Society, the State Public Health Dentist, and members of the press, which satisfactorily demonstrated all operations of the fluoride handling and treatment process. On September 2, 1952, the system was placed in continuous operation.

The source of the fluoride ion from the start of operations to the present has been sodium silicofluoride. It is added to the plant effluent in amounts sufficient to produce a concentration of fluoride ion throughout the distribution system of 1.2 ppm from October 1 to May 31 and 1.0 ppm from June 1 to September 30. With respect to fluoridation, the Providence Water Supply Board acts solely as the agent of the State Health Department in carrying out their directives relative to the chemical used, the applied dosage, and the type of feeding equipment.

A special pneumatic conveying system transfers the chemical from 400-pound drums to a storage collector supplying the Fluoridizer hopper. The Fluoridizer is a loss-in-weight gravimetric feeder, equipped with a non-flooding gate to prevent any possible overtreatment. The feeder is operated automatically by an electric signalling device to provide a quantity proportional to the rate of flow of plant effluent.

Constantly increasing demands following the addition of four filters in 1940 made it imperative that studies be made relative to again increasing the plant capacity. Accordingly, a research program was started in 1948, consisting of filtration experiments. Twelve glass-tube filters, containing various sizes and depths of sand supported by graded layers of gravel, were supplied with water to be filtered from the coagulated-water conduit. Each experimental filter was equipped with all necessary valves in addition to manometers and rate controllers. Filtration was carried out at rates from 1.75 up to 3.50 gal per min per sq ft, samples of the effluents being obtained for chemical, sanitary chemical, and bacteriological determinations at the start of each run and again at 2, 4, 6 and 8 ft loss of head. Loss of head and penetration readings were taken every two hours until the loss reached 8 ft, at which time the particular unit showing that loss was backwashed and placed in operation at a new rate of filtration.

The studies indicated that sand with an effective size of 0.65 mm and a depth of bed totalling 24 in. would permit increasing the existing 1.76 gal rate to over 3.00 gal per min per sq ft, consistent with long filter runs and an excellent quality of water. The experiment was transferred from the laboratory to a plant basis when filter number 2 was rebuilt to conform to the above characteristics and placed into service in August, 1950.

During the next three and a half years filter number 2 was compared with filters 1 to 9, having sand of 0.40 mm and filters 11 to 14, having sand of 0.46 mm effective size. Samples of the filter effluents were obtained for chemical, sanitary chemical and bacteriological examinations at the start of each run, each morning after, and upon completion of a run. In addition to the sampling program, glass cartridge filters containing absorbent cotton were placed on the filter effluents, to observe whether any coagulated material was passing through the sand. It was at times necessary to remove filter number 2 from service for backwashing before completion of a run. Due to the coarseness of the sand in this filter, undesirable amounts of iron were passing through during the winter season whenever the loss of head reached 4½ to 5 ft.

From all experimental data, which began in 1948, and the plant-scale observations, it was concluded that higher rates of filtration, up to 3.50 gal per min per sq ft, could be used satisfactorily without impairing the high quality of the plant effluent, by limiting the maximum effective size of sand to 0.55 mm. Fortunately, these conclusions were reached at a time when the increasing demand during the summer months was accelerating to the point where maximum plant capacity would have to be increased to meet the loads without further delay. This was evidenced by the fact that during the summer of 1953 it was necessary to operate the plant on 89 days at effluent rates far in excess of the normal 61.6-mgd capacity.

Consequently, a contract was entered into in the amount of $95,327 to rebuild the necessary filters and metering facilities. Work under the contract began on January 19, 1954, and progressed satisfactorily to completion on June 26, 1954. It necessitated rebuilding only 9 of the 14 filter units, since filter

number 2 had been rebuilt in 1950, and the effective size of the sand in filters 11 to 14, inclusive, was sufficiently coarse to permit the higher rate of 3 gal per min per sq ft. The effective size of the sand used in the rebuilt filters ranged from 0.50 to 0.55 mm with the average size at 0.52 mm.

Based on a rate of filtration of 3.0 gal per min per sq ft, the plant capacity was increased to 105 mgd, representing an increase of 43.4 mgd over the previous capacity of 61.6 mgd. To accomplish this increase by new construction, based on an estimated unit cost of $60,000 per mil gal of plant capacity, any new facilities would have represented a construction cost of approximately $2,500,000.

Since completion, the rebuilt filters have been in continuous service. Numerous tests have shown that the filters have produced the same excellent quality of effluent water at the higher rates, as evidenced by the following tabulation, showing the quality of plant effluent produced since use of the 0.52-mm sand and high-rate filtration began, as compared with that produced during the previous 14 years.

	October, 1940-June, 1954		July, 1954-February, 1959	
	Maximum	Average	Maximum	Average
Color	13	6	13	6
Iron	0.20	0.01	0.20	0.01
Manganese	0.04	0.00	0.01	0.00

The percent of portions tested showing the absence of coliform organisms were as follows:—

October, 1940-June, 1954	July, 1954-February, 1959
99.86 %	99.88 %

Operation since 1954 has not continually been carried on at the 3-gal rate; the normal operation is at a 2-gal rate, this being increased to 3 gal per min per sq ft when the demand so requires. The following tabulation shows the average amount of water filtered per filter run during the two periods discussed previously:

	October, 1940-June, 1954	July, 1954-February, 1959
Average mil gal filtered per filter per run	16.09	16.86

It may be seen, therefore, that the change to the coarser size of sand, increasing the plant capacity from 61.6 mgd to 105 mgd, has produced the same high-quality water, consistent with a large amount of water filtered per run.

A program of replacing worn and obsolete filter-effluent gate valves, installed in 1926 and 1940, was started in 1954 and completed in 1958. The 28 valves now installed, representing a total cost of $47,988, have demonstrated a most satisfactory performance for this major improvement. Each butterfly valve, which performs the combined function of flow control and positive shutoff in a most satisfactory manner, replaces four original valves, the combined operation of which was not in any sense comparable with the new installation.

With the demonstrated successful operation of butterfly-type valves on the filter-effluent piping, a program of replacing the worn 24-inch wash-water gate valves, installed in the years 1926 and 1940, is contemplated this year. Extensive tests and observations of wash-water requirements have been made relative to valve sizing, velocities, speed of opening, sand expansion, and rate of rise of wash water through the filters. This information has been applied to the flow characteristics of butterfly-valve design, and a contract entered into for the purchase of two, A.W.W.A. specification, motor-operated butterfly valves for this purpose.

A Master Plan development for improvements at the Water Purification Works contemplates a total estimated expenditure of $1,100,000 and includes major building changes, to permit maximum economy of operation and provide additional room for chemical treatment, storage and handling, laboratory research, group instruction, main entrance lobby, approach driveways and parking areas. Included also are new and enlarged power-transmission cables with expanded transformer capacity, and a new power-distribution center with provision for increased power circuits.

In addition to the improvements and extensions of the Purification Plant, a 40-mil gal underground concrete reservoir is to be constructed near the Scituate Aqueduct in the city of Cranston. This project has been under consideration since 1940, and with the steadily increasing demands on the distribution system,

it was concluded that any further delay at this time would seriously affect the ability of the distribution system to meet peak loads and to provide the proper and safe amount of storage required for fire-protection purposes. The total estimated cost, excluding land, has been set at a figure of $2,150,000.

A two-story addition, together with alterations to the Administration and Operations building was completed in 1954, at a contract price of $348,855. The new addition, approximately 27 ft by 143 ft, adjoins the original building and houses the meter and accounting office, ledger-card room, public relation and application office, engineering office, board room, and chief engineer's and secretary's office. Engineering records, meter records, billing room, meter readers' office, carpenter shop, toilets and rest-room facilities are provided along the street side of the original building. Automobile repairs and stock, meter testing and repairing, general stock, and garage facilities for all automotive and construction equipment are provided at ground level in the main building. Off-street parking facilities for visitors and all departmental employees are provided in the yard area in the rear of the building. Small pipe stock, fittings, hydrants, etc., which are required in daily operations, are stored in the yard area, which is effectively screened off from the adjoining residential section by a fence of evergreen trees.

At Providence, as in other water works, we have been faced with demands for increasing amounts of excellent-quality water at low cost. Necessary changes in treatment, together with improvements and extensions, have met the challenge in the past, and with work now in progress under our Master Plan we feel sure that the demands of the foreseeable future will be satisfied in the efficient manner characteristic of the water-works profession.

USE OF BUTTERFLY VALVES ON WATER DISTRIBUTION SYSTEMS

BY A. E. HATCH, JR.*

[*Read April 16, 1959.*]

Evidently from the increase in interest in rubber-seated butterfly valves for distribution service, there is a need for better valves for this application.

What are some of the reasons behind this increased interest in butterfly valves?

FIG. 1

Dramatic evidence of what can happen in the event of a line break that could not be isolated quickly is shown in Fig. 1.

From this, it would appear evident that damage could run into thousands, and perhaps hundreds of thousands of dollars, should a critical valve fail to respond in an emergency.

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After discussing this with distribution men and engineers throughout the country, we have compiled a list below of features required for the perfect distribution valve.

The ideal distribution valve should:

1. Be easily operated by one man, even after long periods in one position.
2. Be leakproof after thousands of operations.
3. Require no lubricant after installation.
4. Resist corrosion.
5. Be without pockets to collect debris.
6. Be self-cleaning.
7. Have a full-sized waterway.
8. Be compact.
9. Have a low head loss.
10. Have ample safety factor for withstanding surges.

All of these things add up to one big requirement—RELIABILITY. Comparing the rubber-seated butterfly valve to these requirements, we find the following (see Fig. 2):

We have the non-corrosive metal-to-rubber seating. By

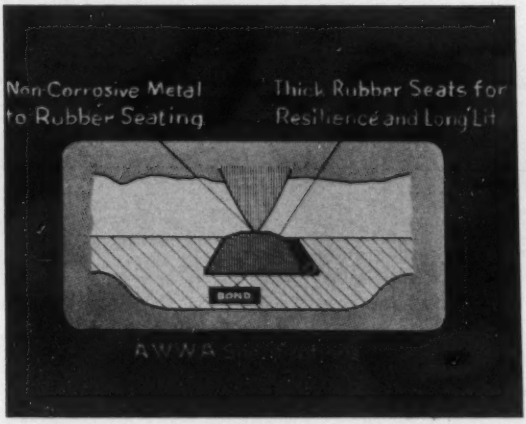

FIG. 2

employing a material that has a "give" to it, as in the rubber seat, we have eliminated any metal-to-metal contact that dictates wear with each operation. We also have a valve that can be manufactured very tight—in fact, bubble tight—and remain in this condition after thousands of operations. The noncorrodible seating edges on the valve disc meet the rubber, eliminating the possibility of jamming or freezing after long periods in the full-open or full-closed position.

Further to assure ease of operation, the butterfly valve comes equipped with a totally enclosed, permanently lubricated gear reducer, giving the operator a mechanical advantage of at least 70 to 1, and greater in the larger sizes.

FIG. 3

Going back to tightness again, in Fig. 3 we see a demonstration of the bubble tight test that all rubber-seated butterfly valves sold to American Water Works specification must pass. Note the pool of water on the top of the disc. Here air pressure is exerted under the disc at a pressure of 125 psi, or as re-

quired by the valve class, for a period of not less than five minutes, and one bubble escaping into the water pool is enough to eliminate the valve. This is one of the most rigid tests devised for valve leakage, and the butterfly-valve AWWA Specification is the only AWWA valve specification that has this requirement.

Dramatic evidence that butterfly valves are tight after installation is presented by the fact that when 104 gate valves were replaced with AWWA butterfly valves in an eastern filter plant, they resulted in an actual water saving of 33 mgd.

The low maintenance requirements of a valve are basically inherent in the design of a butterfly valve. You will note that the only movement from full open to full closed is the rotation of the shaft and disc through an arc of approximately 90° (see

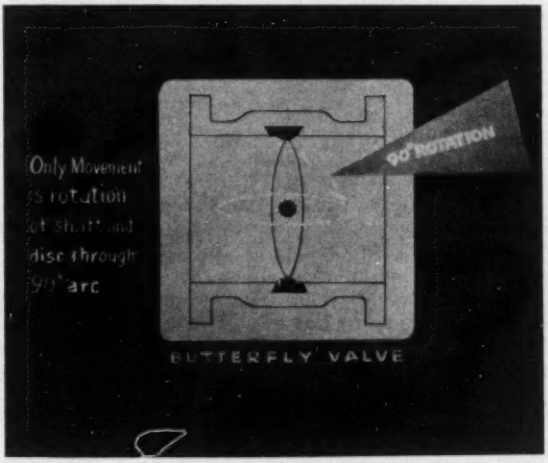

FIG. 4

Fig.4). The bearings are permanently lubricated and entirely out of the waterway where the initial lubrication lasts the life of the system. They are also protected by the rubber seat so that dirt cannot enter them.

The distribution valve must also be resistant to corrosion. We have covered this point on the seating surface where we have a perfect seat to withstand corrosion. The other parts of the valve exposed to the waterway are normally cast iron, alloy cast iron, or utilize various types of rubber coatings, all well known for their corrosion-resistant properties.

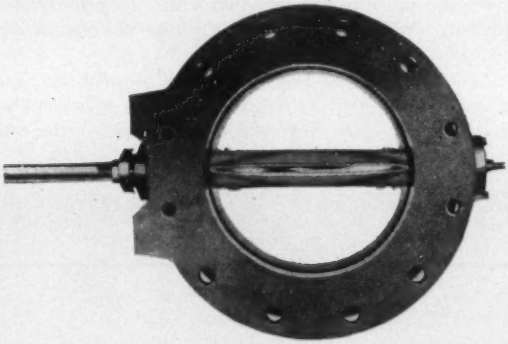

FIG. 5

Looking at the basic butterfly-valve design in Fig. 5, we see that it does not have a full line size waterway. How important this is depends mainly on the size of valve and the type of system the valve is installed in. In smaller lines, where cleaning with a rabbit or any traveling cleaning mechanism is used, it appears undesirable to use butterfly valves at all locations. However, where the line is concrete or of other material not requiring cleaning, or in larger sizes where less than line-size valves are normally used anyway, this is not a factor.

Head loss of the butterfly valve is low, amounting to approximately three-tenths of a velocity head with the valve in the wide-open position, or about the same as an elbow.

In addition to the inherent features in the butterfly valve that make it adaptable to distribution service, the user also has the added protection of an American Water Works Association specification, to assure him that he gets the proper materials in shafting, bearings, body, and seating surfaces (see Fig. 6).

Not only are materials specified, but their thickness and strength is also outlined.

Note on the picture that where taper pins are used, they must be mechanically secured, bearing loading must be under 2500 psi at rated shutoff pressure, and a thrust bearing must be furnished to maintain the valve disc in a center position.

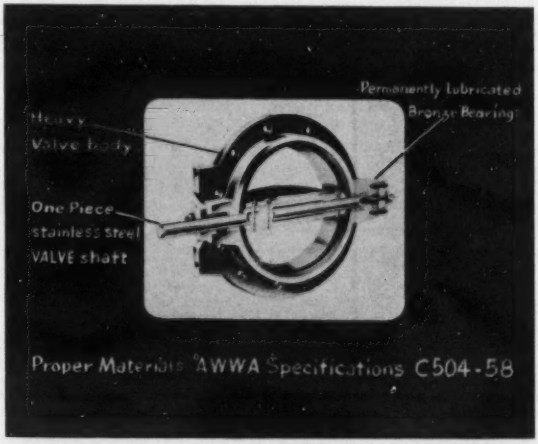

FIG. 6

While the AWWA specification is as complete as it is practical to be, there are some very important choices that are left up to the manufacturer and the customer. It is not the intent of this paper to discuss the pros and cons of each type of construction. However, we do want to point out a few of the major choices that are available.

The AWWA specification divides the valve into six classifications: 25-8, 25-16, 50-8, 50-16, 125-8, and 125-16. The first group of digits indicates the shutoff and leakage test pressure in pounds per square inch gauge, and the second group indicates the maximum pipeline velocity in feet per second. The specs further break down the operator torque requirements for the

most adverse condition, which is a dry system downstream when the valve is closed, and the least adverse condition, which is a flooded system downstream when the valve is closed (see Fig. 7). In the least adverse condition, the operator may be sized down to meet the actual torque requirements of the system, providing it is of sufficient size to overcome the unseating torque requirement of the valve. Under the most adverse conditions, the operator torques are listed in the specifications and cannot be deviated from.

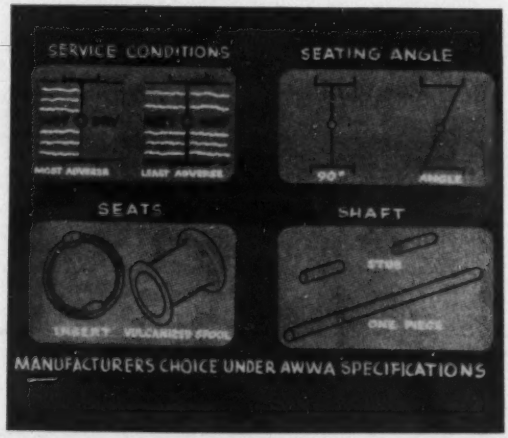

FIG. 7

Two types of shaft construction are allowed, the first being the solid one-piece through shaft, and the other the two-piece stub type protruded into the disc from each end, utilizing the valve disc itself as the center portion of the shaft.

The two types of seat allowed are the molded ring insert, cemented and clamped into the valve body, and the vulcanized spool type.

Valve discs may seat at 90° to the pipe axis when the insert-type seats are utilized, and at less than 90° to the pipe axis in the vulcanized spool-type construction.

Each manufacturer feels that he has valid reasons for selecting the design he did, and he will be glad to go over his reasoning with you.

In considering valves on distribution service, the most prominent use that comes to mind is, of course, the isolating valve. In this application, the stuffing box on the valve would be totally enclosed, and the gear reducer furnished suitable for submergence underground or water levels up to 20 feet. The reducer comes equipped with connections for transite or cast-iron pipe sleeves and can be furnished with nut operators on the valve reducer, or extended up to just below the ground surface in a valve box. Other applications in distribution systems that a butterfly valve would adapt itself to are in pump suction and discharge, as altitude valves at the base of storage tanks, and as throttling or pressure-control valves.

The use of the butterfly valve on pump discharge as an automatic check valve is shown in Fig. 8. The system is arranged so that the pump starts up against a closed valve and,

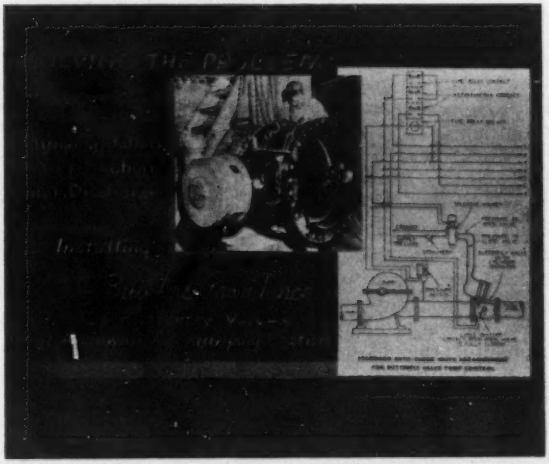

FIG. 8

as the pressure rises to a predetermined level, a pressure switch actuates a 4-way solenoid valve, causing the valve to open at a rate that is adjustable. Upon shutting down the system, the valve closes first to prevent any back flow through the pump and, upon reaching the closed position, trips a limiting switch, thus shutting down the pump motor. This application takes the place of a check valve and a shutoff valve and, when hydraulically operated, has the advantage of an adjustable speed of opening and closing, to eliminate water hammer in the system. Auxiliary manuals may also be provided for emergency operation.

The pump check system can also be designed around an electrically operated butterfly valve.

In use as an altitude valve, the basic cylinder-operated butterfly is combined with a type of controller that opens the valve when the system pressure decreases, allowing the water-storage tank or reservoir to feed into the system. The valve remains open until the water-storage supply is refilled to a predetermined level and then closes, maintaining the designed storage capacity.

As a pressure-control valve (see Fig. 9), the butterfly valve has the advantage of low head loss in the wide-open position when control is not necessary, and bubble tightness when the system is shut down. In throttling service, the butterfly valve has always been noted for its good control characteristics.

Getting down to the actual physical requirements of installing the butterfly valve, we find that normally valves are furnished with flanged ends. However, adapters are available for connections to almost any kind of piping that is required, and the manufacturers are slowly converting their valve patterns to include these various type ends. It is best when considering a valve in the system to allow the manufacturer to quote either way, in order to assure the most economical installation.

For valves installed above the ground, there are available all standard types of operation, such as hydraulic, pneumatic, or electric. In buried installations, the most common types are shown in Fig. 10. Of the two, the advantage lies in the type with the horizontal shaft, as it requires a more shallow excavation, and any sediment that is in the bottom of the pipe line is flushed away from the seat, due to the Venturi action when the

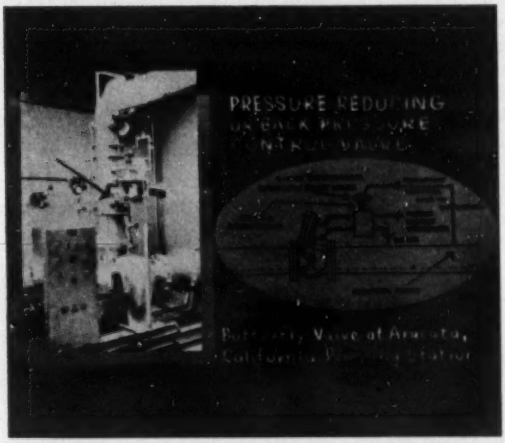

FIG. 9

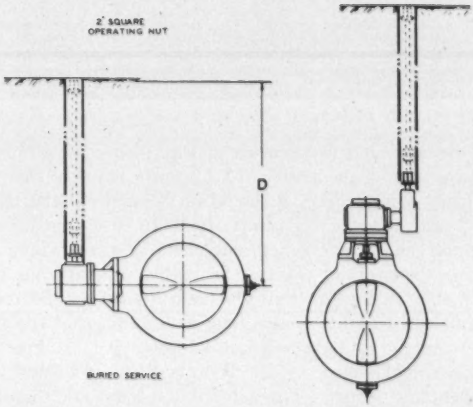

FIG. 10

valve approaches the closed position. It should be noted here that the butterfly valve is a truly balanced valve and does not require the use of by-passes to utilize pressure on each side of the valve prior to opening, and that it can be installed in any position without construction modifications.

We have seen some of the good points of butterfly valves; now let's see if we can pull them apart under actual conditions that can occur in a distribution system.

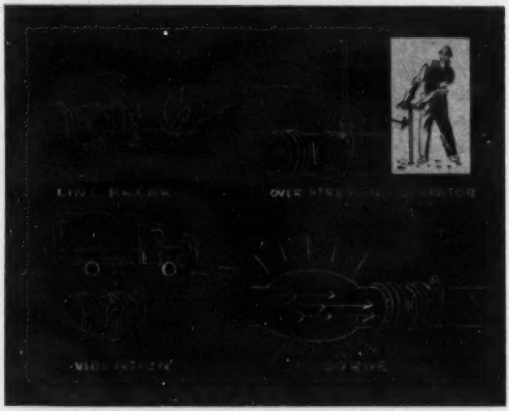

FIG. 11

In the upper left hand corner of Fig. 11, we see a line break, and the question of the ability of a butterfly valve to close under high velocity arises. First, it should be pointed out that the flow of water past the valve disc always tends to close the valve; thus the operator, in an emergency, only acts as a governing device to regulate the speed of closure. Secondly, in analyzing a situation like this, it appears that the velocity cannot go too high in a normal distribution system, due to the fact that the friction increases rapidly with the increase in flow. For example:

Assume a wide-open 36″ AWWA class 125-16 butterfly valve in a distribution system. The valve is located 10,000 equivalent feet from a constant 100 psi (231 ft.) supply with a normal flow

of 12.0 MGD (2.7 fps). The normal loss through this system is approximately 10 feet (C = 100).

In the event of a complete line break, what is the maximum velocity that would be encountered?

$$\text{Basic Formula: } V = \sqrt{\frac{\triangle H \times 2g}{Cp + f\frac{L}{D} + 1}}$$

$\triangle H$ = System head loss—feet of water (231 ft max.)
Cp = Butterfly-valve loss coefficient (.3 at full open).
f = pipe friction factor (.02).
L = System equivalent length in feet.
D = Valve diameter in feet.
V = Line velocity in feet per second.

$$\text{V max.} = \sqrt{\frac{231 \quad (64.4)}{.3 + .02 \ \frac{(10{,}000)}{3} + 1}} = \underline{\underline{14.7 \text{ fps,}}}$$

which is well within AWWA classifications and the valve limits.

At this point, we also should analyze the forces acting on the rubber seat. Butterfly valves of the angle-seated type with vulcanized spool seats, or the 90° seating type with cemented and clamped seats, are all designed with a seal behind the seat, which does not permit water or pressure to get under the seat. This means that all line pressures are working on the outside or waterway side of the rubber, and under positive pressures with the valve in the open position, the water is holding the seat in place. As the valve approaches the closed position, the differential pressure across the seat builds up until at the closed position we have the full system differential of up to 125 psi. In testing our rubber seat, we have found it to withstand differential pressures of almost 400 psi across the seat without rupture. On top of this reasoning, there are also in actual service rubber-seated butterfly valves on line service where velocities are over 30 ft per second daily, and we know of one where the velocity is over 50 ft per second.

It also might be pointed out that the rubber seat in a butterfly valve acts something like a safety valve, and if excess line pressure builds up, it bleeds off across the seat to bring the pressure back to normal without damage.

In the upper right-hand corner of Fig. 11, we see a man overstressing the valve operator by applying too much torque to the gear reducer. In analyzing this situation, we note that the stops that limit the rotation of the disc are in the gear reducer, external of the valve itself. In the 90° seating design, overtorque could damage the stops; however, the valve itself would still be intact, as the disc could rotate in the pipe line. Repairs can be made to the valve from the outside, which would not require dewatering or depressurizing the system. In fact, the disc can be put in the closed position, and as it is balanced, it would remain in that position during the repair operation.

A simple shear pin or slip clutch in the arrangement of the operating nut could prevent damage to the valve or operator, and it is wise to incorporate this in your designs.

The valve must also remain in the required position without creeping due to vibration.

As the torque to operate the valve disc is exerted by the operator through a self locking worm and gear reducer, the valve will stay in its last position, which, in a distribution valve, is normally either full open or full closed. In the full-closed position, the 90° seating valve is balanced and physically held in place by compression of the rubber seat around it, and the operator can be removed safely. This ring also helps absorb any vibration and prevents opening and leaking of the valve, if vibration tended to cause the gears to back up.

As we pointed out before, the purchaser is protected by AWWA specifications with ample safety factors to withstand line surges or water hammer. The physical safety factor in the AWWA specifications means a 125# valve can withstand surges up to 300 lb without permanently damaging the valve itself. We have actually tested 50# valves with one-piece stainless steel shafts with differential pressures of 300 psi across the disc and found no misalignment of the bearings or wear or infringement on the bearing surfaces.

In summary, it can be said that the butterfly valve has many advantages that make it attractive as a distribution valve, and unless the system has a pressure requirement greater than practical for modern rubber seats, we shall be seeing more and more usage of this reliable valve.

WATER-DEPARTMENT PLANNING

BY CLARENCE E. FERRY*

[*Read May 21, 1959.*]

The title of this paper, "Water-Department Planning," can be considered analogous with water-department management or organization. Planning, by necessity, is practiced by individuals in all forms of undertakings. However, when two or more persons engage in a mission, a sound and definite plan of organization is essential to manage any enterprise successfully.

Many statesmen have said that survival and world domination depend upon *power*, whether it be in the form of water power, oil, gas, atomic, solar, or a combination of all.

Many also agree that a nation will deteriorate, unless an adequate water supply is available to contribute to its health, welfare and economic advancement. What pertains to the nation also affects the status and progress of the states, the cities and the townships.

Basically, the water-department management has, in the eyes of the public, only *ONE* duty to perform! That is, to supply potable water in sufficient quantities, to satisfy the demands of residential, industrial, commercial and municipal consumers for the highest standards of living, manufacturing, recreation and the protection of property from the ravages of fire.

Actually, *these are* the functions of the water department, and (with a few exceptions and regulations) they must be carried out expediently and efficiently.

Water is a natural resource that must be delivered to the consumer free of impurities and fit for human consumption. A water department is a utility, as are electric, gas and communications. How many water-works managers and commissions have really thought of their department as a utility, on a par with that of electric and telephone? Large water-department districts, precincts, and private systems do operate as utilities and are

*Superintendent of Distribution, Water Department, Manchester, N. H.

constantly checked by State and local commissions, directors, and stockholders.

The 18,000 water systems in the United States serve a population of 125,000,000. The present total force of water-department employees numbers 130,000, an average of 1 water-works employee to serve every 1,000 people. Municipalities own 70% of the water utilities and serve about 90% of the population receiving water service.

Regardless of size, all water utilities must start with the same natural resource, process it, and deliver the same under identical conditions, although in some cases it is on a smaller scale with less customers involved. However, it should be noted that the smaller the department, the larger percentage each employee represents of the total staff.

Yes, the WATER industry is a utility, but it is unique in two categories:

1. The sun, air and water are absolutely necessary for human survival. Of these three only water is delivered as a product, having no known substitute in sufficient quantities.

2. The fact that there is no substitute automatically makes the product a monopoly, and therefore it will have no direct competition.

The significant fact is that management can utilize the energy and ability of the personnel toward supply, pumping and treatment plant, distribution, and personnel and public relations, knowing that the demand for the product will be constantly increasing and that it will never be obsolete.

Planning can be considered the most important function of water-works administrators. So much depends on the decision of policy and designs determined by the governing board.

Many of our oldest systems reflected sound planning some 50-75 years ago, as many of the supplies and distribution systems served adequately, up until some two decades ago. During the past 25 years many sections experienced prolonged droughts, with the lowest annual rainfall ever recorded. In 1953, 1,072 public water supplies in the United States were forced to restrict the use of water to all or part of their 24,000,000 customers. Record temperature deficiencies for the northern

climate even during the past winter have made us all bury the mains and services deeper.

The amount of moisture nature produces cannot be increased nor altered appreciably; rainfall and run-off records for the past 100 years show what can be expected. The United States has no absolute shortage of water, but conservation and control must be practiced, as the demands increase at a startling rate. Over all America, it is estimated that our need for water will grow 270% in our lifetime!

Ground-water tables are dropping. Watersheds and supplies can become contaminated, due to the increased recreational load.

Since all these extremes have happened in our lifetime, with records of the past as a basis, we *can* and *must* prepare our systems for the future. We even know approximately what is ahead:

1. It is known that the population will increase some 50,000,000 by 1975.

2. Statistics show that the daily per-capita rate has been increased, by the use of:

a. Automatic dishwashers and washing machines.
b. Air conditioning (see Fig. 1).
c. Automatic lawn sprinkling.
d. Modern industrial needs.
e. Increased standard of living.

This daily per-capita rate increased from 120 gpd per person in 1940 to 160 gpd per person in 1958 (see Fig. 2). Predictions are that by 1975, the per-capita rate will increase another 25%. Barring a catastrophe, this problem must be solved in the very short time of some 15 years. Fortunately, as shown in Fig. 3, the number of leaks per mile of main and per 1,000 services decreases as the length of mains and the number of services increase (see Fig. 3).

The responsibility of meeting the forecasted demands and initiating the recommended future policies rests squarely on the shoulders of the water-utility boards and their administrations.

Water Supply

The water supply is the foundation of the whole water-utility structure. Without an adequate supply the town would soon deteriorate, being unattractive for industrial expansion and the high living standards demanded by the present-day population.

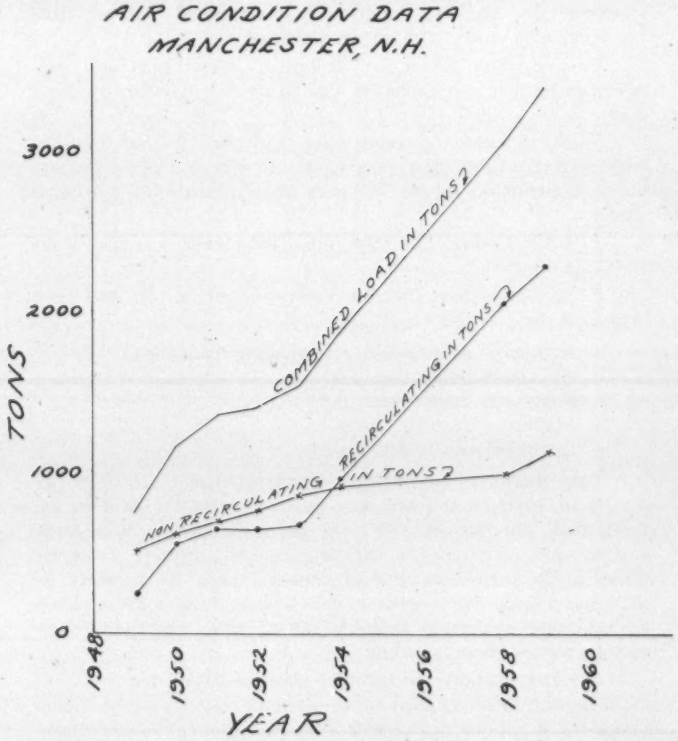

Fig. 1

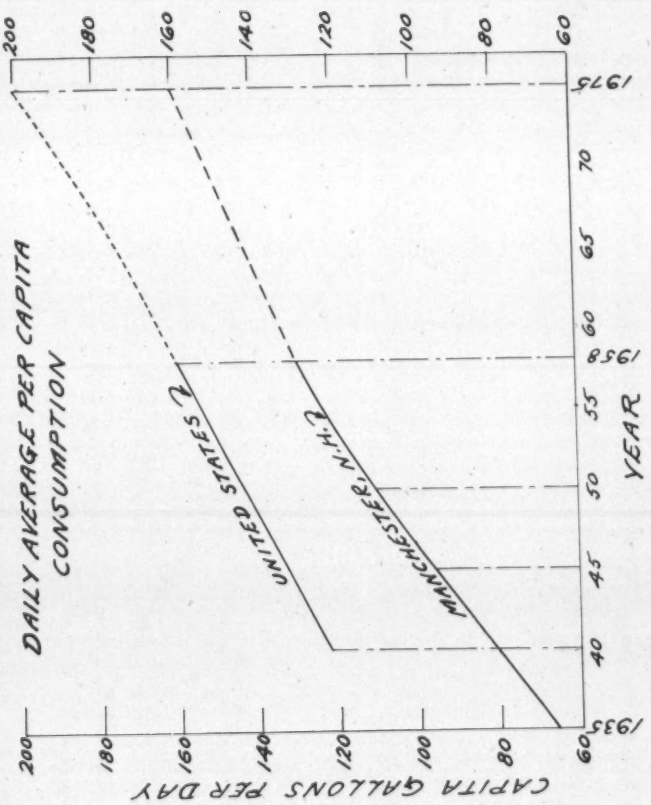
DAILY AVERAGE PER CAPITA CONSUMPTION
CAPITA GALLONS PER DAY
200
180
160
140
120
100
80
60
1975
1958
1933
70
65
60
55
50
45
40
YEAR
UNITED STATES
MANCHESTER, N.H.

FIG. 2

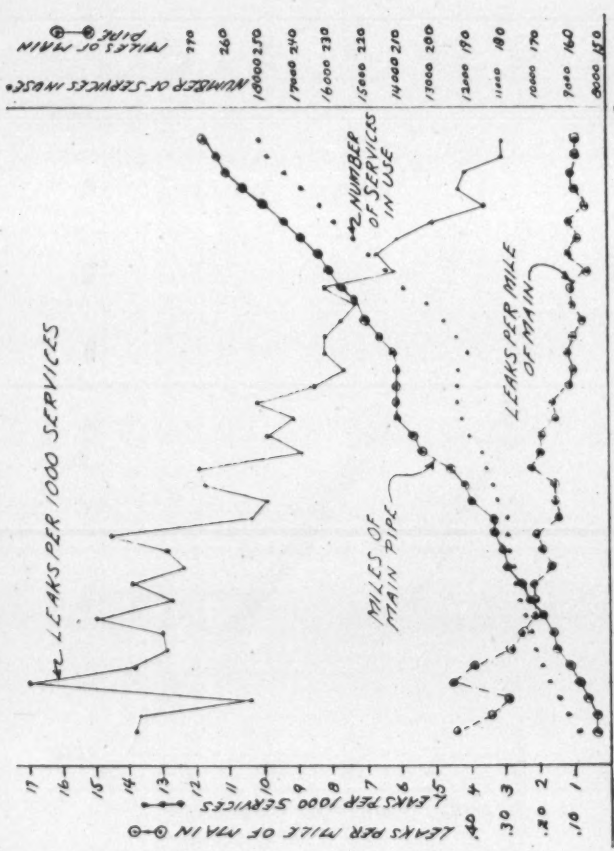

FIG. 3.—DATA ON MANCHESTER (N. H.) WATER DEPARTMENT

Unless the present water supplies are adequate to supply the 200%-300% anticipated increase, one must plan now how best to add to the supply.

Investigate new well sites for reserve. Purchase and control surface-water supplies before they are taken over for recreation or camp sites, or contaminated from industrial waste. Watersheds need constant protection by enforcing regulations to eliminate fires, contamination, and wanton destruction of dams and control works of impounding reservoirs. Forestation can be beneficial and necessary, if operated properly. This program, its operation and cost form a separate function, which will be described in detail in another paper.

Pumping facilities and treatment plants need to be maintained, designed for future expansion, and reinforced by emergency standby units.

The facilities of transmission and distribution are an integral part of the city structure (see Fig. 4). The consumers are more cognizant that actually there is some work involved in water distribution, when they see hydrants, municipal swimming and wading pools, water-main construction and maintenance crews, and even the meter reader who appears periodically.

Finished water, storage reservoirs and standpipes should be adequate to satisfy the National Board of Fire Underwriters at their periodical inspection.

The problems in supply and distribution are familiar to all water-works operators, as every customer expects uninterrupted, continuous service upon demand. Oftentimes management is called upon to solve numerous individual complaints, the result being that little or no time is left for the more important basic operations.

With the present mechanized age with everyone cost-conscious, all the energies of the superintendent, management and engineering staff are taxed to the utmost. Future plans for distribution reinforcements for 5-10 years in advance, with forecasted costs, must be formulated. After the method of payment is determined, and the go-ahead signal given, the work must be carried out expeditiously.

Communities involved with the national accelerated highway-construction program have an added responsibility of incorpor-

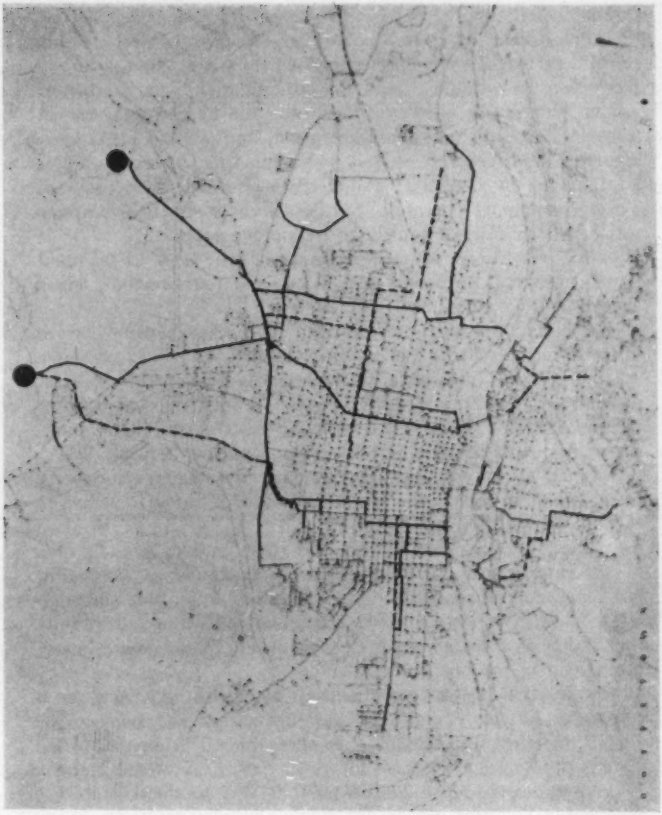

FIG. 4.—DISTRIBUTION SYSTEM, MANCHESTER, N. H.

ating designs for future water-main distribution in conjunction with the highway contracts. This is no easy matter, and oftentimes the tendency would be to "*just get by for the present.*"

The planning time is here now; the interstate system will not wait. Therefore we must consolidate our personnel, or if necessary engage consulting firms and contractors, to facilitate the completion of the best distribution system possible. What excuse can management offer, if, in a short time after the interstate highway completion, it is necessary to jack a new, larger pipe across the right-of-way at, say, $100 per ft, when by planning and installing at the proper time the cost will be some 25% of the jacking cost.

Money spent on planning and construction timing will be saved in the long run.

We have at our disposal water-works supplies conforming to rigid standards, with a length of life far exceeding expectations. The challenge to the water departments is to install and maintain these appurtenances to be trouble-free equally as long.

A majority of emergencies originate from faulty installation, faulty supervision, and damage from vehicles and other utility construction, all of which are man failures. Cooperation and coordination by all utilities and contractors will save much inconvenience and unnecessary expenditures.

In some of the larger water departments, 50% of the expenditures are allocated solely for payroll—i.e., wages to employees, working for and in all phases of the utility functions. Their training and attitude can be very influential toward improving public relations and the effective discharge of their proper functions, as prescribed by management. Personnel is the foundation and keystone of the structure of any organization. The proper placement of personalities in a job is not easy, when one considers that the type of job is first determined, and then a qualified person must be found to perform its functions. Usually those persons interested in their work will be the most valuable to the organization and able to carry out assignments efficiently.

Management must be able to select, train and utilize good employees, if efficient service is to be rendered in this present day of automation, mechanization and technological advancements.

More time should be spent in screening new employees, with the thought in mind of promotional advancement within the organization, rather than selecting a poor or mediocre employee on a costly "we will try him out" basis. Once mutual management-employee cooperation has been established, periodic meetings, outings and constant employee-level inter-department communication will produce the results for which all managers strive:—efficient personnel.

The fact that potable water must be available at all times necessitates continuous surveillance of supply, treatment and distribution maintenance—i.e., in darkness, week-ends and extremes of weather conditions.

The National Safety Council places utilities, with lumbering and heavy construction, third from the most dangerous occupation in the past 3 years. The mining and marine-transportation industries top the utilities as being more hazardous. All parties suffer when absenteeism is caused by sickness or accidents. It is the duty of both employer and employee to keep equipment in good repair, practice safety on the job and at home, and have safety equipment and first-aid material available when needed.

A well trained and satisfied personnel can be very influential toward maintaining good public relations and, therefore, public good will. By its very nature, every public water utility *has* had public relations ever since it started business.

Even privately owned utilities find *public good will* most necessary to success in their rate cases and defending their franchises against public ownership.

Oftentimes extra advance notice and explanation of why the water is to be curtailed, and why inconvenience due to construction is necessary, will calm tempers and criticism. How simple it is to supply service through temporary by-pass lines, thus minimizing hardship to the customer and also guaranteeing good workmanship, even though the work is prolonged, due to unforeseen circumstances.

Every precaution necessary to produce a safe water must be taken by water-department management, as they realize only too well their responsibility and liability toward delivering a

commodity so essential to the community's health, progress and beauty.

Studies already completed show that the water industry has fallen behind other utilities and other industries in providing incentives, training and opportunities to engineers and other trained people, and at the critical time when the water industry faces its biggest job in history.

The departments have done a marvelous job by keeping up with the increasing demand, while working on a budget that has usually been inadequate to maintain the physical plant and operating staff in prime condition.

Today, as always, the cost of water is the biggest bargain in the family and industrial budgets. Commissioners and managers are sincere public servants, and when supported by the public and adequate rates, no community will be kept from advancing by inadequacies of any utility. There is a vast job to do, and "Silent Service Is Not Enough" to get public appreciation and support for the modernization required in this, not the atomic age any more, but the "Computer Age," able to calculate probabilities far beyond the realm of comprehension.

FORESTRY AT MANCHESTER WATER WORKS — FACT OR FANCY

BY ALDIS J. CHRISTIE*

[*Read May 21, 1959.*]

The definition of forestry is "the art of producing and managing a forest," and with this paper I shall attempt to tell you what we are doing about it here at Manchester Water Works.

Compared to many other industries in this country, forestry is rather new. In Europe, forestry has been practiced many centuries, but it is only since about the year 1900 that the word, "forestry," has been used to any extent in our vocabulary, and, until recent years, with few exceptions, there has not been much interest shown in the profession. It has been a long uphill haul to stimulate real interest in forestry and its related subjects.

Many factors have entered into the picture to promote this interest, and of course the most important one is the fact that good quality lumber and the desirable species were being cut much faster than they were growing.

Around the turn of the century and before 1910 in New Hampshire alone, which is considered the center of the white pine area, the annual cut of white pine was about 700 million board feet. Since that time, the cut has gone down steadily and is now less than 200 million board feet annually, and is still declining. Years of clear cutting and the suppression of pine by poor grade hardwood species have been the two most important factors for this condition.

The foresters, lumbermen and interested industries finally realized that if the very important wood industry was to survive, some immediate action should be taken. Therefore through an accelerated educational program, research, and pest and disease control, forestry has been given a much-needed shot in the arm and is rapidly coming into its own.

Perhaps many of you men here today can recall that many streams, that you knew and fished in when you were boys, have

*Forester, Water Department, Manchester, N. H.

gradually dried up. Invariably, the reasons for this condition could be traced to the fact that somewhere on the watershed that fed these streams, clear cutting of the forest cover had been made, with the result that no growth was left to help retain the water in the soil for a gradual runoff throughout the year.

Near the turn of the century, a few interested, far-sighted men saw the handwriting on the wall. Timber was being cut very rapidly for many reasons. The country was growing and growing fast. Wood was needed for this expansion, and very little thought was being given to a future supply. The policy was to cut out and get out. The eastern part of the country, being the first to be settled, was the first to be cut, and, as the country grew and expanded toward the west, the lumber industry went west also, cutting and leaving great waste areas along the way.

Finally, the west coast was reached, and there the industry thought that an inexhaustible supply of lumber had been found. This was not so however, and the few hardy believers, who for many years had been fighting this destruction, could now say, "I told you so." Then the forestry profession began to make headway.

Forest conservation became a popular topic of conversation. The hunters and fishermen were concerned because the game was disappearing. The people as a whole began to miss the green forests. The question was asked, "What can be done about it?" The few foresters who existed at that time should have all the answers.

The government set aside areas in all sections of the country for game preserves. Many states followed closely. Many town forests were established, and as forestry became more popular, individuals who owned large areas became interested.

Many municipal and private water companies suddenly realized that they owned or controlled many acres of land. Very little, if any, of this land had been acquired for forestry purposes, and perhaps not too much had been acquired for water-conservation purposes. However, regardless of the reasons, these water companies realized that they owned the land areas, and many decided that something should be done. Old fields

and other open areas were planted, usually to evergreen species. In most cases, little thought was given to these reforested areas, and the same held true regarding the areas that supported natural growth. As the years passed, these areas grew, and the trees developed to the size of merchantable timber, and stumpage was sold to be manufactured into various products.

Forestry as a useful profession became more popular. Schools that taught forestry were looking for areas where experiments and field work could be carried out. The best example of this type of watershed forest is, I believe, owned by the New Haven Water Department and has been managed for many years by the Forestry Department of Yale University.

This has been only a brief resume of the development of forestry in this country. It is surprising to note that Manchester Water Works has followed the general pattern.

As you probably all know, the first Water Board came into existence August 1, 1871. Manchester was growing rapidly, and farsighted city officials realized that an adequate supply of water must be had.

When Massabesic Lake was chosen for the supply, a land-buying program for shore-line control was begun, and in order to acquire the shore line, many extra acres were purchased. It was soon realized that many acres of land were owned, and the far-seeing Water Board, through advice from both the Forestry Department at the State University and the State Forestry Department, instigated a tree-planting program on the old fields and other open areas.

The first planting was made in 1913, when 40,00 white-pine seedlings were set out. The next year 50,000 seedlings were transplanted, and nearly every year thereafter some forest planting has taken place on our watershed. We have planted as many as 155,000 trees in one year for a total planted to date of 1,840,000. Many species have been planted, which include White, Norway and Scotch pine, arborvitae, white and Norway spruce, white fir and white ash. The fir, arborvitae and white ash were more or less experimental plantings and were not too successful, due to poor site conditions, or because they were planted outside their natural range.

White spruce was planted primarily for Christmas trees,

and, although they grew very well, we soon discovered that, beginning about two or three weeks before Christmas and again for several weeks in the early spring, they disappeared for various reasons. These plantations were successful as far as growth was concerned, but unless one is able to protect white spruce during certain times of the year, you might as well forget them. For these obvious reasons, we have discontinued planting or trying to grow white spruce.

Most of our future planting will, no doubt, be either Norway or white pine, running heavily to Norway pine. There are several reasons to favor Norway pine planting over white pine planting in this area. With proper cutting practices in white pine areas, we should be able to get an ample supply of white pine reproduction.

Most of our future planting will be done on newly purchased open areas, where Norway pine does very well, and we also have found that thinnings can be made in Norway pine plantations earlier than in white pine. As yet, Norway pine is not too susceptible to disease or insect damage in this area; it will grow well on most sites; they are not a tolerant species and so grow well in open areas, and the method of thinning that is best for Norway pine is also the most economical method to use.

Using this method, we remove a complete row of trees, either every other row or every fourth row. If every fourth row is removed, you can plan to return in a few years and remove the middle row of the three rows left.

The time of the first thinning is very closely related to the size of material to be removed and the market for the material removed. Here in Manchester we are very fortunate to have several wood-working industries, which can use and so will buy thinnings down to a minimum 3-inch top-diameter size.

The more complete utilization of the trees cut, the better forest conservation is being practiced.

Let me give you one or two examples of utilization on our watershed. This year we have been thinning a white pine plantation that was planted in 1920, which now makes it 39 years old. It had a light thinning about 10 years ago and was ready for another one this year. Our markets were such that we decided to cut these trees into three different products. First, we had

many good-sized butt logs, which were suitable for saw logs, and so were channeled to our sawmill; next a near-by cooperage mill, which manufactures wooden buckets and tubs, agreed to take most of the remaining tree, and that portion of the tree left which was unsuitable for saw logs or cooperage was cut into four-foot pulpwood. This operation was a contract job. The cutting and yarding was let out to one contractor, and the hauling to another. The costs of the operations were as follows: cutting of saw logs and cooperage was done for $8/M; yarding of these logs to the skidway was done for $4/M, and the hauling was done for another $8/M, so for $20/M this material was cut and delivered to the purchaser, and he paid us $32/M. This is a difference of $12/M received over operating costs. The low cost of yarding for this particular job was due to a smooth, flat logging chance and a very short haul from the lot to the skidway.

The pulpwood market at the present time is not too lucrative, and so we do not produce any more of this than is necessary. The cost of the pulpwood operation is $6/cd. for cutting, $3/cd. for yarding and $7/cd. for delivery. This is a total cost per cord of $16, and prices paid are $18/cd,. or a difference in operation cost and price received of $2/cd. This is not very much, but working out the pulpwood accomplishes several things for the betterment of the stand. First, of course, it gives complete utilization of materials cut; next it tends to remove most of the branches from the main stem, which, when well scattered, lies close to the ground where it deteriorates very rapidly, thus reducing the fire hazard.

As you can now see, integration of the materials cut in this operation has provided material for three phases of the wood-manufacturing industry: the larger and best logs for lumber, clear joints for cooperage, and pulpwood for the paper industry.

Another cutting of interest that we made in one of our younger stands took place two years ago. This operation was in an 18-year-old Norway pine stand on a very poor site. The soil was light and rocky. The history of the area is as follows, It had once supported a poor growth of white pine, which was cut clean, and soon afterwards the area was burned over.

Then for a period of about 25 years, the area was heavily pastured, and when we acquired the land, a considerable amount of erosion was evident. Soon after we bought the land it was planted to 3-year-old Norway pine seedlings. In 1957, New England Pole & Wood of Merrimack, N. H., needed several thousand 8′ and 10′ farm fence posts. We supplied them with 3,423 eight-foot and 1,737 ten-foot posts. In addition, we removed 13 cords of pulpwood for the paper industry. Here again we had nearly complete utilization by an integrated operation. Contract labor was again used, and the final results costwise were as follows: to cut, yard, and deliver 5,160 posts to Merrimack cost $1,551.10; to cut and yard 13 cords of pulpwood cost $117.00, or a total cost of the operation of 1,668.10. This material was sold for a total of $2,143.45, or a return on the operation of $475.35, or less than 20 years after planting, a return of $19.01/acre.

Fifteen years ago this operation probably would have been impossible, because at that time, there was little or no market for this type and size of material. This change in the markets is a good indication of what the wood-using industry has been doing for the last decade or so in their efforts to find new markets for as much of the materials grown as possible. We foresters believe that this is only the beginning. Eventually, through the continued efforts of all people dependent on the forest industry for a livelihood, a use will be found for most of the material that once was considered waste.

I have mentioned these two operations to point out that much-needed cultural work can be carried out in the younger age-class stands on at least a break-even basis, and many times at a profit.

Early cultural work in young healthy stands is, in my mind, one of the most important phases of forestry. To have a good forest one must plan to develop the species of trees that will have the most value at maturity and will grow best on the types of soil available. In order to do this, these trees must have room to grow and, therefore, the undesirable species must be eliminated. There are many methods by which this can be accomplished. The most popular and economical method used today is by the use of different chemicals. In this, as well

as other areas, these chemicals have been developed to eliminate the broadleaf species. Research has developed several different methods of application, and when used as directed, and for the purpose intended, very good results have been achieved. The best methods are foliage spray, basal spray, and by insertion directly into the tree itself. Great care has been used in developing these chemicals because of the many factors involved: Chemicals had to be found that were unharmful to fish, game or domestic animals. Care had to be taken when using these chemicals, especially around water supplies, so that no contamination would result. Here again by cooperation with everyone concerned, research has done an excellent job. Some of the chemicals being used are ammate, 2-4-D, C.M.U. and many others, most of them doing the job well.

Growing a good forest can be compared to growing good vegetables. In order to raise carrots, beets, corn or other crops, weeds must be eliminated. The same condition holds true with forestry. If we intend to grow the species of trees best suited for a particular area, then the poorer species and weed trees must be eliminated.

Another important phase of cultural treatment in a forest is pruning, especially when the main species is white pine. White pine has the characteristic of retaining its limbs after they die from lack of side light in the stand. In order to produce a high-quality board, these limbs must be removed as early in the life of the individual tree as possible, and the best way to date of doing this is mechanically.

A pole saw is usually used. We usually prune about 150 healthy well-formed trees to the acre to a height of 12 to 17 ft. The cost of this operation is about 1 cent per running foot. At present lumber prices, one knot-free 8-inch board, 12 ft long, cut from a pruned butt log, will return the cost of this operation compounded annually for 50 years. If a tree is pruned when it is 6 in. in diameter and is then allowed to grow until it reaches 18 or 20 in. in diameter, you can visualize the amount of clear lumber that can be cut from a pruned log. An unpruned log will usually produce only #4 common boards, which at the present time are worth about $86/M. Selects, or lumber produced from pruned butts, are worth $227/M and up.

I think these figures answer the question, "Is it profitable to prune?"

Other cultural problems that may arise in any forest program are the possibility of attacks from insects and damage from disease or fire. Compared to other sections of the country, we have been very fortunate and have been relatively free from all of these. We do have small amount of white pine blister rust, and of course some damage from the white pine weevil. About every five to seven years we have an outbreak of the gypsy moth, which feeds almost entirely on the deciduous species, and especially the oaks. As most of our hardwoods are of poor quality, we do not get too much concerned, however, over these infestations. There are many new methods of control with which to combat these outbreaks when they arise. Any of these insects or diseases are a serious threat and should be closely checked.

Forest fires are always a possibility, and to help combat them our department built its own fire-lookout tower a year after the 1937 hurricane. This tower was designed by our engineers and built from material cut from our forest. We man this tower 7 to 8 months a year, and in addition to keeping a close watch over our own property, we cooperate with the State forest-fire control system and assist them in locating fires in the surrounding areas. This service gives adjacent towns much-needed fire protection that otherwise they would be without. We also own and maintain a fully equipped fire truck.

The last phase of our forest operations is our sawmill, where we saw all lumber removed from our forest. The lumber is cut selectively during the fall and winter months and is sawed into square-edge boards and dimension during the early spring. It is then stuck and air-dried for a period of 6 to 8 months. After the drying period, bid invitations are sent out to 10 or 15 nearby reliable lumber dealers, who, if interested, submit their bids on a given date, and needless to say, the lumber goes to the highest bidder.

Our lumber is well manufactured and at the present time is as good as, if not of better quality than, the average run of native pine. At the sawmill we have a newly installed chipper. With the exception of the sawdust, this machine grinds all of

our sawmill waste. Previous to this year slabs were either sold or given away. The edgings were hauled by truck to the dump and when weather conditions permitted, were burned. The sawdust was given to anyone who would haul it away.

Early this spring I was approached by a group of farmers who, due to a shortage of cattle bedding and chicken litter, were looking for a constant and guaranteed supply of this material. This shortage has been caused by recent new markets for clean sawmill waste. The wood dealer, who for many years used our slabs, reached the retirement age, which left us without any market at all. The combination of these two conditions worked out very well for us, as you can see. It not only gave us a new outlet for our slabs, but it has also given us a market for our edgings and clippings, which we had not had before. In adding this new equipment to our sawmill operation, we are now able to utilize and sell all the waste products from our mill. The number of cords of this material that will be produced is, as yet, not known. We have made an estimate that for every thousand feet of logs sawed, we shall produce at least two cords of bedding. By observing the amount already made I feel that this estimate was low.

The sawmill operation itself is not unusual. We saw all square-edge lumber; it is well manufacured and stuck, and the market is good. Our annual cut is between 250,000 and 300,000 board feet. We harvest less than we are growing, and in years to come our annual cut should be much larger.

Many of you, no doubt, have in the back of your minds these questions: Why practice forestry on a watershed? What is the best type of growth to have on a watershed, if any? How does forest growth help the flow of water? I think the best answers to these and other questions, pertaining to watershed forest cover and its treatment, can be found in an excellent article, read before this group in Februray, 1958, and printed in the December, 1958, issue of the Journal of the New England Water Works Association. The title of the paper is "The management of Forested Watersheds in New England" and was written by Howard W. Lull, Chief of the Division of Watershed Management Research, and Norman R. Tripp, Chief,

Section of Watershed Management, both United States Forest Service men stationed at Upper Darby, Pa.

Briefly, some of the advantages derived from the practice of forestry here at Manchester Water Works are as follows. Since 1940 our department has used nearly 400,000 board feet of lumber cut from our forest and produced in our sawmill. This item alone amounts to a considerable saving over buying it on the open market. From this lumber we have manufactured boards and dimension timbers for buildings and cement forms, furniture for our office, plank for truck bodies, side boards and tail gates, blasting plugs, wedges and blocking for our pipe crews, bulletin boards, grade stakes for our surveying crew, lumber and timbers for bridges on the watershed, and for our pipe cat-walks, which support our water mains that cross the Merrimac River.

When our new office and garage was built in 1951, all of the window sash was made from our lumber. These are only a few of the items supplied to our department from trees removed in our yearly forest operations.

We have transplanted many trees from our watershed to areas around our two pumping stations, low-pressure reservoir, and office and garage property. These trees were all transplanted for landscaping purposes.

Each year we entertain several classes of forestry students from our State University. These tours act as an outdoor classroom, where these forestry majors are able to observe first hand the results of our many operations. We also cooperate in any way possible with Federal and State Forestry Departments here in New Hampshire. By doing these things, we feel that we are contributing somewhat to the general forestry educational program.

Perhaps I have unintentionally given you the idea that we have a perfect forest and forestry program here at Manchester. Let me say right now that this is not so. We have made mistakes and no doubt will continue to do so. However, we do try not to make the same mistake twice.

The whole forestry profession still has a long way to go before we have a thorough knowledge of forestry. However, with the help of Federal and State organizations, industry concerned

with forest products, many municipalities, educational programs, research, and interested individuals, we are making rapid progress in getting some of the answers.

Regarding our forest here at Manchester, a great deal of credit is due the group of men who nearly fifty years ago started our forestry by establishing many plantations on our watershed, and to the many members of our Water Board during the past two decades, who as far-sighted individuals, have sponsored forestry as a byproduct to the very important business of furnishing water to a community the size of ours. I personally like to think of Past Superintendent, Percy A. Shaw, as the "Father of Forestry" here at Manchester Water Works, for it was through his efforts that a definite forestry program was instituted in the early 1930's. Since his retirement, this program is being continued under the direction of our present Superintendent, James A. Sweeney.

I hope that this paper has given you some idea of our forestry program, what we are trying to do, and, with nearly 8,000 acres of forest land very suitable to growing white and Norway pine, what the potential can well be in years to come.

In closing, I should like to leave with you one important thought, which is that lumber is the only natural resource that is renewable. When coal, iron, oil or any of the other natural resources are once produced and used, they are gone forever, but we can always renew our supply of lumber if it is properly conserved and nurtured.

SPECIAL USES OF CEMENT-LINED PIPE OF LARGE SIZE

BY WALTER A. ARNOLD*

[*Read June 18, 1959.*]

The subject of cement-lined pipe is not a new one, especially to the water-works industry of the New England States. Cement-lined pipe of various types has been used here for many years. Jonathan Ball is credited with the original idea of cement-lining pipe back in the middle 1800's, but for quite a number of years little use was made of the idea. Late in the 1800's, as more complete water systems were being engineered and built, cement linings were extensively used both for service-pipe lines and transmission mains. From that time to the present cement linings have become a very important part of the water-works industry. Many water pipe lines are being reconditioned and cement-lined, to restore them to their original carrying capacities. The cast-iron industry in the late 1920's and early 1930's recognized the necessity of cement linings in water pipe, and it has practically been an accepted standard in many sections of the country, where water conditions require metal piping to be protected from tuberculation. Other types of lining materials have been tried but have not proved as practical as cement lining.

This brief history and introduction point out the fact that the water-works industry is very familiar with cement linings—their life expectancy, their practicality, and their ability to insure the delivery of pure potable water through any type and size of pipe line. Yet, it is our belief that not all water-works men and/or engineers have fully considered the possibilities cement linings offer them, especially with regard to the use of steel pipe. It will be the aim of this short paper to point out some of these by citing some specific examples.

A few years ago a new pumping station was built by the Cambridge Water Department. The piping in this installation was fabricated from steel pipe. It was possible by this method to get smooth sweeps, bends and reductions in connection with

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the varied sizes of piping required, and thus to minimize the space normally necessary. All of this was possible because the critical internal surface could be protected by cement lining. Piping in this installation varied from 36 in. to 12 in.

Recently it was necessary for the city of Newton to install a 12-in. pipe line across a bridge. Originally, when the bridge was erected a square tunnel had been built into the structure for some such contingency. Unfortunately, the space was not large enough nor properly accessible for normal methods or types of water pipe. It was large enough for the normal outside diameter of the pipe-size required, but not for a bell or a coupling. The job was simply and quite easily done by using cement-lined steel pipe in standard single random lengths, welded together. To get the pipe from one side of the bridge to the other, a steel cable was snaked through the tunnel and attached to a bulldozer on one side of the bridge and to a skid bracket that was welded on to the first length of pipe on the other side of the bridge. As the bulldozer pulled a length into the tunnel, the next length was welded on.

To digress for a moment and answer a question which possibly has come to some of you about the welding of cement-lined pipe, let me say that this is and has been a common practice for quite a number of years. There is no damage to the cement lining caused by welding. The coefficients of expansion for cement and iron are very close, and by using proper standard welding methods a good joint should be routine. The normal care that is necessary for making any joint a good joint is all that is required.

To cite another example: The town of Somerset, Mass., found it necessary, as many others have, to obtain additional water supply. Their only recourse was to obtain the additional water from the city of Fall River. This necessitated crossing a river about 1,000 ft or more wide. The pipe could not go on the bridges, as they were drawbridges, and therefore it must necessarily go on the bottom. Investigation by the engineers showed that two welded steel lines had been installed across the river by the local gas company and were considered very satisfactory, having been in service for a number of years. The engineers, after further investigation and consideration, decided to install a similar line for water. Welding samples were submitted

to the engineers, along with wrapping-material specifications, and a complete piping specification was drawn up by them. The piping they decided on was 12-in., ½"-wall, black steel, cement-lined pipe with bevel ends in standard single random lengths. This pipe was wrapped with 6-in. plastic tape, lapped 3-in., after being welded together. The tape was protected during installation of the pipe by a thin corrugated shell. Dresser expansion joints were installed to compensate for possible movement of the pipe line. The steel pipe line was connected to existing cast-iron pipe lines of the two systems by a Dresser reducing coupling, a standard coupling made particularly for connecting cast-iron pipe to steel pipe of the same nominal size.

There are many other specific examples of the uses of cement linings, such as an installation at Cutler, Me., for the Navy Department's V.L.F. Radio Station. A network of piping, varying in size from 24-in. to 6-in., fabricated into various sections and connected with Dresser couplings, will act as the discharge for a cooling system devised for certain areas in this tremendous installation. Other installations for the Navy Department consists of steel cement-lined pipe lines of many different sizes for fire protection on dock areas. This pipe was used because of the lesser weight of steel pipe as compared to iron, and also for its much greater ability to span open areas, because of its strength without the necessity of excessive numbers of supports. These lines many times are used as salt-water fire systems. This type of piping is ideal for many bridge crossings for the reasons just outlined.

Many industries use cement-lined pipe for transmission of corrosive liquids, such as the paper business, where it is used extensively for carrying bleach liquor. Metal contamination would be ruinous to this manufacturing process, and they look to cement-lined pipe for protection against such an occurrence. Usually these lines run quite a distance from the liquor storage tanks to the processing area. Most of them are suspended or bridged and again use the strength of the steel pipe to minimize the number of supports required. E. I. duPont de Nemours & Co. at their Pennsville, N. J., plant have an 18-in. pipe line, which carries the brackish and corrosive waters of the Delaware River for cooling one of their production processes. This line is cement-

lined cast-iron pipe underground and cement-lined steel above ground. The above-ground piping is carried on support columns, which cover the plant yard like a forest. Again the versatility of cement-lined steel pipe is evident from the standpoint of weight, strength, etc.

As a last example of what can be done with this type of piping we cite the new Wagner Generating Station of the Baltimore Gas & Electric Co. of Baltimore, Md. The piping for this station is mostly cement-lined steel, fabricated and equipped with flanged ends. There are between three and four hundred pieces, varying in diameter from 2½ in. to 12 in., and consisting of many shapes and dimensions from 2½″ x 6″-long spool pieces to 12″ x 20′-long manifolds, with 12 or more outlets of different sizes on the run and at different points of the outside circumference of the pipe. Conceivably it would be almost impossible to design the piping for other materials. Cement lining makes such fabricated jobs possible and permanent, and it is our belief that many water-works pumping stations could be more easily designed in a like manner.

To sum up, it has been the aim of the writer to point out, by a few examples, the possibilities cement lining affords the water-works designer, engineer, and utility, to vary his or their thinking when selecting piping material for specific jobs that do not fall in the category of the standard distribution system.

CONTAMINATION OF GROUND WATER BY SYNTHETIC DETERGENTS

BY I. LAIRD NEWELL* AND FREDERICK O. A. ALMQUIST**

[*Read September 21, 1959.*]

About four years ago, chemists began to notice that persistent foaming was present in water from a number of well supplies that showed chemical and bacteriological evidence of contamination. Chemical analysis of these waters revealed the presence of synthetic detergents. Subsequent to this discovery, it has been the practice in one of the authors' laboratories to test all samples from well supplies for foaming and the presence of synthetic detergents. Table 1 gives results of analysis of samples from some private domestic well supplies, showing foaming and unsatisfactory chemical and bacteriological results.

It is possible for the soil to act as an efficient filter for a time and remove the objectionable bacteria, yet allow synthetic detergents to pass through and show chemical evidence of contamination. Results of analysis of a few cases of this type are given in Table 2. These show the fallacy of depending on bacteriological results alone for the safety of water supplies. For more than three years, tests for detergents have been made on all samples showing suspicion of contamination. The results of tests of a few of these are given in Table 3. It is to be noted that the variation in amount of detergent can be wide. It has also been found that the magnitude of foaming is not necessarily a measure of the amount of detergent present. Odor seems to be present in a majority of instances where detergents are found, but this is not always the case.

The problem of detergents is not confined to small domestic supplies, but may also be found in large industrial and municipal wells.

Detergent Composition and Consumption

In recent years, both domestic and industrial users of detergents have consumed increasing amounts of the synthetic types.

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TABLE 1.—SAMPLES FROM PRIVATE DOMESTIC WELL SUPPLIES SHOWING FOAMING AND UNSATISFACTORY CHEMICAL AND BACTERIOLOGICAL RESULTS

Sample No.	Well	Location	Nitrogen				Chloride	Odor	MPN
			Ammonia	albuminoid	Nitrite	Nitrate			
492511	112′ deep, sealed 26′ from surface	75′ from septic tank 100′ from another septic tank	.150	.155	.0048	.14	11.0	faint sour	240
492710	100′ deep	85′ from septic tank	.003	.095	.130	1.55	49	petroleum	240
496917	55′ deep	70′ from cesspool	.84	.080	.0064	8.0	21	musty odor	5.1
504600*	—	75′ from septic tank	.210	.250	.008	.36	9	strong cabbage	16

* New house and well—used 2½ months with satisfaction, then strong odor appeared. Analysis made after 4 months.

TABLE 2.—SAMPLES FROM PRIVATE DOMESTIC WELL SUPPLIES SHOWING FOAMING AND CHEMICAL EVIDENCE OF POLLUTION, BUT SATISFACTORY BACTERIOLOGICAL RESULTS

Sample No.	Well	Location	Nitrogen				Chloride	Odor	MPN
			Ammonia	albuminoid	Nitrite	Nitrate			
497254	86′ rock few feet below surface. Sealed 8′ down	50′ from 1 septic tank 75′ from another septic tank	4.05	.55	.056	3.3	22	Decayed vegetable	< 2.2
495720	130′ deep—new—2½ mo. old	100′ from septic tank in a development	.465	.070	.0062	.23	14	faint	< 2.2
497173	115′ deep—rock 15′	100′ from septic tank	.003	.025	.014	2.0	16	faint earthy	< 2.2

TABLE 3.—SAMPLES FROM PRIVATE DOMESTIC WELL SUPPLIES SHOWING PRESENCE OF DETERGENTS

Sample No.	Well	Distance from septic tank	Nitrogen				Chloride	Odor	MPN	Foaming	Anionic detergent
			Ammonia	albuminoid	Nitrite	Nitrate					
498085	115′	100′	0	.015	.002	2.9	9	faint	< 2.2	trace	2.2
503555	120′	100′	.480	.050	.006	5.5	17	strong decayed	< 2.2	considerable	11.0
503543	—	—	8.14	1.00	.060	2.6	20	disagreeable	< 2.2	heavy	22.0
502021	85′	75′	.108	.035	.058	8.5	13	none	3.6	slight	.13
502828*	26′ dug (55 years old)	76′	.320	.080	.0012	22.0	11	medicinal	<2.2	moderate	4.0

* 25′ from dry well for kitchen drainage.

For the year 1958, 72% of the total soap and detergent production was of the synthetic type and by 1965 it is expected that as much as 80% of the total soap and detergent output will be synthetic (1).

Table 4 shows figures for 1950 and 1958 and an estimated figure for 1965 for soap and synthetic detergent production. The magnitude of the problem can be noted by figures of billions of pounds per year.

TABLE 4.—PRODUCTION OF SOAP AND SYNTHETIC DETERGENTS

Year	Soap (million pounds)	Synthetic (million pounds)	Percent synthetic of total
1950	2,485	1,093	30.6
1958	1,138	2,951	72.2
1965 (estimated)	940	3,760	80.0

Synthetic detergents, commonly called "Syndets," are now used in the home to an even larger extent, and the amount is estimated to be about 90% of the total.

A conventional, high-foam, home-laundry detergent composition is shown in Table 5. The first two ingredients are the basic detergents. The phosphates are secondary detergents and are also dispersing and water softening agents. The silicate is the corrosion inhibitor. The carboxy methyl cellulose aids in soil suspension. The sodium sulfate introduces an electrolyte, which aids detergency.

TABLE 5.—COMPOSITION OF CONVENTIONAL HIGH-FOAM HOME-LAUNDRY DETERGENT

	Parts
Alkyl Aryl Sulfonate	15
Fatty Alcohol Ethylene Oxide Sulfate	5
Tetra Sodium Pyrophosphate	10
Sodium Tripolyphosphate	40
Sodium Silicate (Meta)	5
Sodium Sulfate	15
Sodium Carboxy Methyl Cellulose	0.5
Perfume and Color	q.s.
Optical Dye	0.03

Because of their chemical composition, Syndets do not form insoluble compounds with calcium, magnesium, iron or aluminum and are not affected by "hard" water. Conflicting statements have been made on the effects of synthetic detergents on bacteria. Dyer (3) states: "Germicides are activated by surfactants at low concentrations. This activation increases up to the critical micelle concentration. With further increases, the germicidal activity decreases and may even become less than it was with no surfactant at all."

Synthetic Detergents

More than 250 manufacturers now produce the surface active agents used in synthetic detergents. These surface active agents, known as surfactants, can be divided into three types, depending on their ionic activity. The cationic surfactants, frequently used as textile softening agents and disinfectants, but not as household detergents, are commonly quaternary amines, producing an organic positive ion. The cationic surfactants are classed as highly toxic (4). The nonionics, as implied, do not ionize in water and depend on the complete organic molecule for their properties. They are most frequently used in low foaming composition. The nonionics, used to a small extent in houeshold detergents, are classed as having moderate toxicity (4). Since nearly all of the household detergents and the great majority of the industrial detergents are of the anionic type, this surfactant is most widespread. A partial list of household detergents using anionic surfactants includes Dreft, Tide, Joy, Vel, Dash and Duz. These surfactants produce a positive sodium ion and negative organic ion when dissolved in water.

The formula for the household detergent given in Table 5 has 15 parts of anionic surfactant listed as alkyl aryl sulfonate. When the aryl group is benzene, the compound is known as ABS, alkyl benzene sulfonate. The laboratory tests for synthetic detergents depend on the detection and determination of ABS. The methylene blue test used by us is given in detail in Appendix A (5).

Usually the contamination of ground water may be detected by foaming of the water if the amount of anionic surfactant ABS is in excess of 1 ppm. Figure 1 is a photograph of bottles con-

taining 1, 5 and 10 ppm, recently shaken, to show the amount of foam produced. The foam produced is not necessarily proportional to the amount of detergent present.

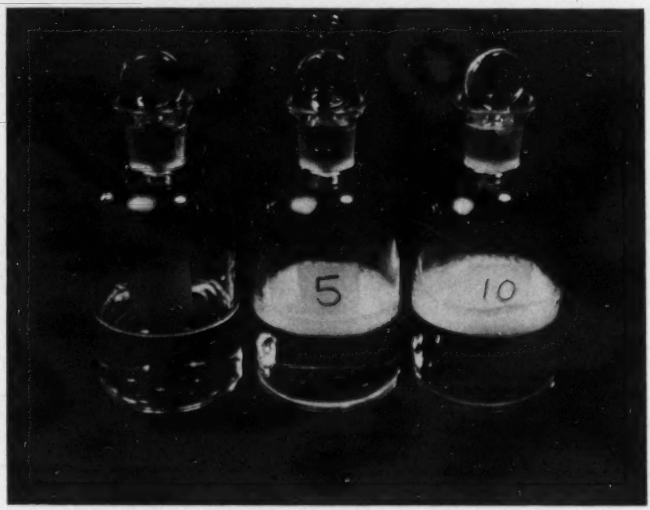

FIG. 1

GROUND WATER-CONTAMINATION

During the early part of February, 1958, investigations were made of consumers' complaints of oil taste in water from two large wells—one 10″ in diameter, capacity 500 gpm; the other 16″ in diameter, capacity 750 gpm—supplying a town with a population of more than 13,000. These wells, constructed in 1947, are about 150 ft apart and are located near a small stream, as shown in Figure 2. Across the stream and 500 to 600 ft from the nearest well (10″) is a lagoon, used for receiving industrial wastes from metal-cleansing, cutting and similar operations. A second lagoon is also nearby. Chemical analyses and bacteriological tests showed no evidence of pollution from septic tanks or

other harmful sources; however, the presence of anionic detergent indicated pollution from some source, such as industrial wastes. In spite of the presence of a flowing brook, showing no detergents, between the 10″ well and the lagoons, the anionic detergent was traced to the lagoons. It was found that a considerable amount of industrial cleaner, containing synthetic detergents, was being discharged into the lagoons. This has now been stopped, and no Syndets are being received by the lagoons. The 10″ well was immediately closed down, and the 16″ well, some 140 ft farther from the lagoon, was put in operation. Periodic checks were made on water from this well and are given in Table 6. The amount of detergent present changed only slightly in more than three months' operation. Therefore it was decided to install curtain wells between the lagoon and the brook, as shown in Figure 2. These wells are each 2″ in diameter and 26 ft deep, and were pumped at a total rate of 200 gpm. The pumping of these small wells effectively reduced the contamination of the large wells. In four months' pumping of the curtain wells, the anionic detergent fell from 10 ppm to 1.16 in the 10″ well and from about 1.6 to 0.7 in the 16″ well. At the same time, the detergent in the curtain wells rose from 1.9 ppm to as high as 20 ppm, but later dropped somewhat, perhaps because of dilution by heavy rains and abandonment of use of the lagoons for synthetic detergents.

An industrial water supply, consisting of two large wells, located in another plant in the vicinity of the lagoons but somewhat farther away than the 10″ and 16″ well mentioned above, have shown 0.6 ppm and 0.5 ppm anionic detergent with no indication of foaming. There has been no other chemical or bacteriological evidence of contamination.

In connection with the search for an additional source of supply for a municipality, some tests were made on a well located about 800 ft from a stream known to carry industrial wastes. An analysis of water from this stream showed anionic detergent present as 1.2 ppm, and a sample from the well several weeks later contained 0.6 ppm.

In a sub-division, three drilled wells, 100 ft deep and apparently carelessly constructed, were contaminated by household detergents from the three appurtenant septic-tank systems fol-

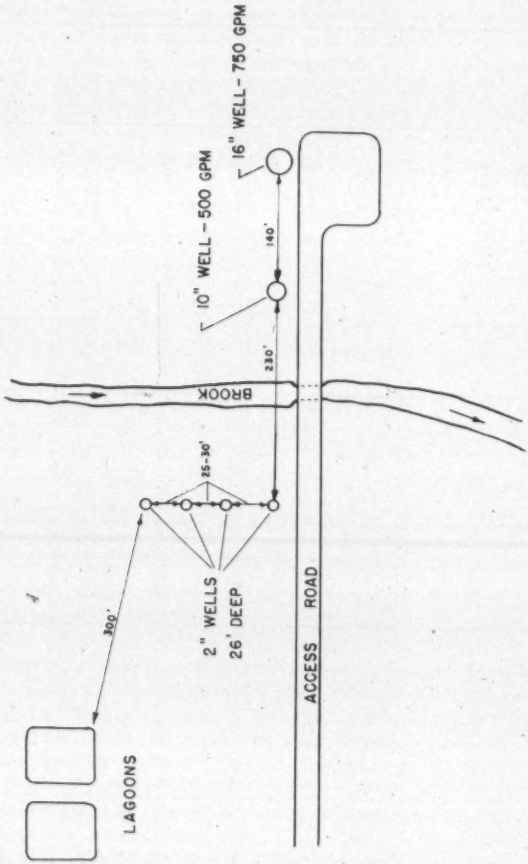
16" WELL – 750 GPM
10" WELL – 500 GPM
140'
230'
BROOK
25-30'
2" WELLS
26' DEEP
300'
ACCESS ROAD
LAGOONS

FIG. 2

TABLE 6.—SYNTHETIC DETERGENTS IN LARGE MUNICIPAL WELL SUPPLY

Date	Anionic detergent (ppm)		Foaming		Odor	
	10″ well	16″ well	10″ well	16″ well	10″ well	16″ well
2-25-58	10	None	heavy	none	resinous	faint cedar
3-19-58	—	1.4	—	slight	—	faint resinous
4-10-58	—	1.8	—	very slight	—	faint hydrocarbon
5-14-28	—	1.6	—	very slight	—	faint hydrocarbon
5-28-58	—	2.3	—	very slight	—	faint hydrocarbon and resinous
6-4-58	—	1.6	—	very slight	—	faint resinous
6-10-58	Curtain Wells	Four 2″ curtain well between lagoons and brook pumped 200 gpm				
6-10-58	1.9	10	—			
6-16-58	5.5	7.0	—			
6-19-58	9.0	2.20	0.6	—	very slight	—	very faint
2-26-58	17.0	1.70	1.16	—	very slight	—	very faint
7-2-58	20.0	1.3	1.6	—	very slight	—	very faint
9-11-58	4.0	1.5	0.7	very slight	none	faint resinous	none
9-18-58	8.8	1.16	0.5	very slight	none	faint resinous	very faint
10-3-58	8.0	1.16	0.7	very slight	very slight	faint aromatic	very faint aromatic

NOTE—A sample of the brook 7-24-58 showed 0.4 ppm anionic detergent.

lowed by leaching at a distance of 75 ft from the wells in each case. These wells were redrilled to a depth of 200 ft with the top 100 sealed off, and no further trouble has been observed from the detergent contamination after a period of 18 months. In another instance, the contamination of a 100-foot drilled well at a distance of 175 ft during a dry-weather period disappeared after heavy rains, and it is believed that the dilution of the ground water, together with a rise in the ground-water level, were responsible for the improvement. The condition has not recurred in a period of almost two years, although the condition causing the contamination has also not recurred.

Sewage-Treatment Processes

Synthetic detergents find their way into the ground water or into streams or surface waters by being carried in sewage, which is discharged either into the ground or onto the surface of the ground. McGauhey and Klein (6) have found that ABS will not interfere with sedimentation, the activated-sludge process or filtration in the treatment of sewage. No significant amounts of ABS are removed by sedimentation, such as in septic tanks. It is believed to have little or no effect so far as the disposal of sewage itself is concerned.

Studies of synthetic detergents in sewage processes by Clair N. Sawyer (7) show that the alkyl benzene sulfonates (ABS), which comprise the largest group of anionic detergents, are quite biologically resistant to decomposition and pass through the normal sewage proceses into the receiving stream without alteration.

Further studies by McGauhey and Klein (6) indicate that ABS can be removed with single-stage activated sludge up to 50-60% and increased to 70-75% by two-stage processes. Trickling filters may remove 25%, although higher figures have been reported. Surface stripping may remove 83 to 92%. In spite of the treatment processes, large amounts of synthetics pass into surface streams and ground water. This inability to eliminate the synthetic detergents in treatment of sewage containing detergents can affect, and has affected, well supplies in the vicinity of streams, where the cone of influence has extended to the stream, and surface water is drawn into the ground water.

Underground Travel

Stiles, Crohurst and Thomson (8), in tests using uranine dye, found that the dye appeared to float in a blanket at, or parallel and close to, the ground-water table. They also found that as pollution travels, it does not appear to expand laterally, but travels as a ribbon and may even contract in long distances.

It is the authors' opinion that the synthetic detergents tend to follow this pattern. In addition, we have noted few cases of excessive vertical diffusion.

In our studies, we have found instances where synthetic detergents have traveled as much as 800 ft horizontally. This long distance of travel seems to be common for many chemical compounds.

Table 7 shows the distance of observed travel of chemical pollutants (9).

Table 7.—Distance of Observed Travel of Chemical Pollutants

Nature of Pollution	Pollutant	Distance of travel (ft)	Time of travel
Uranine	dye	450	—
Chlorinated Sewage	phenols	300	—
Industrial Waste	picric acid	15,840	4 to 6 yr
Industrial Waste Cooling Ponds	manganese, iron, hardness	2,000	—
Garbage Leachings	miscellaneous leaching	2,000	—
Industrial Waste	chromate	1,000	3 yr
Oil-Field Brine	chlorides	1,300	—
Gasoline	petroleum	10,560	—
Weed-Killer Wastes	chemical	105,600	6 months

State and local sanitary codes prescribe distances between sewage-disposal systems and wells which are much less than found for wells showing detergents in some of our tests. Experience, however, seems to indicate that if the wells are properly located with respect to distances and direction of ground-water flow and are properly constructed and sealed, separating distances usually called for furnish reasonable protection, and it is questionable whether changes need be made in the regulations until further studies show the necessity.

Toxicity

Stokinger and Woodward (4) found that the anionic surfactants not containing the sulfonate group were practically nontoxic, but that the alkyl aryl sulfonate types, including ABS, which are most commonly used are classed as mild to moderately toxic.

Since the amount of synthetic detergent that can be tolerated in water over a long period of time without adverse effect on the health and well-being of humans is not known, and since the presence of detergents in any supply is indicative of contamination, it is not possible at the present time to qualify such waters as entirely satisfactory for drinking purposes. However, it is of interest to note that it is possible to ingest synthetic detergent, as a result of brushing the teeth with certain toothpastes and washing dishes and glassware with certain household washing compounds, in greater amounts than might be present in water which is consumed.

In using one of the popular brands of toothpaste and rinsing the mouth normally, there remained in the mouth, as found by rinsing with an additional 200 ml of water, 1.16 milligrams of anionic detergent, or 5.8 ppm.

In washing glasses with a household detergent, commonly used, and rinsing in a normal manner, the glass being allowed to drain dry, the glass was found to contain 0.195 mg of anionic detergent, which would give a concentration of 0.78 ppm if the glass were filled with water.

Removal from Water

Our tests seem to indicate that the anionic detergents are not affected by oxidation or soil bacteria and do not appear to be absorbed by any of the normal soil constituents to any great degree. None of the common chemical treatments of well water, such as chlorination, fluoridation or metaphosphate addition, have any effect on the detergents. The only effective methods for removal of synthetic detergents from potable water, known at this time, is activated-carbon treatment. With small household supplies this can be done with a pressure filter containing granular activated carbon and is economically possible. In the case

of large municipal or industrial supplies, it would be necessary to have treatment and settling basins for use with powdered activated carbon, together with a sand filter to remove any unsettled carbon, and this would be quite costly. According to Renn and Barada (10), it will require 50 to 89 lb of carbon to 1 lb ABS, when the concentration of ABS is 1 ppm, to effect satisfactory removal.

Because of the difficulty in removing synthetic detergents from water, the location of a well in relation to the sewage-disposal system is most important in sub-divisions and other populated areas. Because of contamination of ground water in Suffolk County, Long Island, the Federal Housing Administration requires a minimum-size lot of 20,000 sq ft (11). They also require source of water supply from a water-bearing stratum at least 40 ft below finished ground surface, and that the depth of the well shall be at least 40 ft below the level of the water-bearing stratum, which means the minimum well depth shall not be less than 80 ft. Wells must be cased in watertight casings to a point at least 20 ft below finished ground surface, and be at least 75 ft from a septic tank and 100 ft. from a seepage area.

Research by chemical manufacturers is creating new products daily, and one manufacturer has already announced the production of a sulphonate which has all the cleansing properties of the ABS type and yet can be broken down by bacteria. It is known that the manufacturers of synthetic detergents are cognizant of the problem and are promoting research and studies to eliminate this type of contamination.

Conclusions

(1) The use of synthetic detergents, especially of the anionic type, is growing rapidly and increasing the problems of pollution.

(2) Anionic detergents of the alkyl benzene sulfonate type are generally biologically resistant, pass through soil without change or absorption, and are unaffected by chlorination or other common treatment.

(3) Ground-water supplies containing detergents nearly always show other chemical evidence of contamination but may be satisfactory from a bacteriological standpoint.

(4) Activated-carbon treatment is the only known method for removal of small amounts of detergent from water.

(5) No limits have yet been established for detergents in drinking water, and there is need for further study, in order that some limit might be placed beyond which water should not be used.

(6) Other practices, such as using toothpastes with surfactants and washing glassware and eating utensils with certain household detergents, may contribute to the amount of synthetic ingested.

(7) The number of ground-water supplies contaminated by synthetic detergents is likely to increase, unless new non-polluting materials in the detergent field are developed.

(8) Some control of well pollution by synthetic detergents can be accomplished by proper precautions in constructing a well.

References

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3. D. L. Dyer, "Soap and Chemical Specialties," Vol. 34, No. 12, p. 53 (1958).
4. Herbert E. Stokinger and Richard L. Woodward, Journal AWWA, Vol. 50, p. 526 (1958).
5. Task Group Report, Journal AWWA, Oct., 1958, Vol. 50, p. 1343.
6. McGauhey and Klein, "Sewage and Industrial Wastes," Vol. 31, p. 877, No. 8, Aug., 1959.
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8. Stiles, Crohurst and Thomson, Hygienic Laboratory Bulletin, No. 147, June, 1927.
9. Task Group Report, Journal AWWA, Vol. 49, p. 1339 (1957).
10. Renn and Barada, "Sewage and Industrial Wastes," Vol. 31, p. 850 (1959).
11. FHA Circular Letter No. 77, April 10, 1959.

APPENDIX A (5)

Synthetic-Detergent Content

1. *General Discussion*

1.1. *Principle.* This process depends on the formation of a blue-colored salt when methylene blue reacts with ABS. The salt is soluble in chloroform and the intensity of color is proportional to the concentration. The intensity is measured by making spectrophotometric readings in this solvent at a wavelength of 652 of mμ. The method is applicable in the 0.025-100 ppm (as ABS) range.

1.2. *Interference.* Both organic and inorganic compounds interfere with the determination of ABS. Some of the proved interferences can be predicted on the basis of chemical properties. Organic sulfates, sulfonates, carboxylates, phosphates, and phenols, which complex methylene blue, and inorganic cyanates, chlorides, nitrates and thiocyanates, which form ion pairs with methylene blue, are among the positive interferences. Organic materials, especially amines which compete with the methylene blue in the reaction, can cause low results. Positive errors are much more common than negative when determining anionics in water.

2. *Apparatus*

2.1. *Graduated cylinders,* 250 ml, 100 ml, 25 ml.

2.2. *Beaker,* 600 ml.

2.3. *Separatory funnels,* 500 ml.

2.4. *Volumetric flask,* 100 ml.

2.5. *Glass wool,* pyrex filtering fiber.*

2.6. *Spectrophotometer,* either Coleman Junior† or Beckman Model B.‡ Refer to the instructions with the instruments. Calibration curves should be plotted by running a series of ABS solutions of known concentrations.

2.7. *Glass spectrophotometer cells.* For the Coleman, Selected Cuvettes, 6-300 A, 25 × 105 mm; for the Beckman, Cortex Absorption Cells, 5.00 cm.

3. *Reagents*

3.1. *Standard* ABS *for calibration.***

3.2. *Chloroform,* cp *grade.*

3.3. *Sodium hydroxide,* either approximately N NaOH or approximately 20 per cent NaOH.

3.4. Sulfuric acid, either approximately N H_2SO_4, or cp concentrated H_2SO_4.

3.5. *Phenolphthalein,* 1 per cent in alcohol.

3.6. *Methylene blue chloride,* Eastman No. P573, or equivalent. Dissolve 0.1 g of methylene blue in 100 ml of distilled water. Transfer 30 ml

*Manufactured by Corning Glass Works, Corning, N. Y.
†Manufactured by Coleman Instruments, Maywood, Ill.
‡Manufactured by Beckman Instruments, Fullerton, Calif.
**Obtainable from the Assn. of American Soap & Glycerine Producers, New York.

of this solution to a 1-liter volumetric flask. Add 500 ml distilled water, 6.8 ml concentrated H_2SO_4, and 50 g of the monosodium phosphate. Shake until the solution is complete. Dilute to the 1-liter mark.

3.7. *Wash solution.* Add 6.8 ml of cp concentrated H_2SO_4 to 500 ml distilled water in a 1-liter flask. Introduce 50 g of monosodium dihydrogen phosphate monohydrate, ACS reagent grade, and shake until the solution is complete. Dilute to the 1-liter mark.

4. *Procedure*

4.1. *Preparation of calibration curve.* Prepare a standard solution by weighing an amount of the reference material equal to 1 g ABS on a 100 per cent active basis, dissolving in distilled water and diluting to 1 liter. Pipet 10 ml of this solution into a second 1-liter volumetric flask and dilute to volume with distilled water. Prepare a series of ten separatory funnels, with zero, 1, 3, 5, 7, 9, 11, 13, 15, and 20 ml. of the dilute ABS solution, respectively. Add sufficient water to make the total volume 100 ml in each separatory funnel. Mg ABS (in 100 ml chloroform) = 0.01 × ml of standard solution; plot mg ABS against absorbance.

4.2. *Volume of sample.* The volume of the water sample to be tested is based on the expected ABS concentration:

Expected ABS concentration-ppm	Sample taken ml
0.025-0.08	400
0.08-04	250
0.4-2.0	100
2.0-10.0	20
10.0-100.0	2

If a sample of less than 100 ml is indicated, dilute to 100 ml with distilled water; if 100 ml or more is used, extract the entire sample.

4.3. *Procedure for testing process:*

a. Make the solution alkaline by adding N NaOH, using phenolphthalein as the indicator. Then acidify with N H_2SO_4 and transfer to a separatory funnel.

b. Add 10 ml of chloroform and 25 ml of methylene blue. Rock vigorously for 30 sec and allow the phases to separate. Excessive agitation may cause emulsion trouble. Some samples require a longer period of phase separation than others.

c. Draw off the chloroform layer into a second separatory funnel. Rinse the delivery tube of the first separatory funnel with a small amount of chloroform. Repeat the extraction three times, using 10 ml of chloroform each time. If the blue color in the water phase becomes faint and disappears add 25 ml more of dilute methylene blue.

d. Combine all extracts in the second separatory funnel. Add 50 ml of wash solution and shake vigorously for 30 sec. Emulsions do not form at

this stage. Allow to settle and draw off the chloroform layer through the glass wool into the volumetric flask. Repeat the washing twice more with 10 ml of chloroform each time. Rinse the glass wool and the funnel with chloroform. Collect the washing in the volumetric flask, dilute to the mark, and mix well.

e. Determine the absorbance of the solution at 652 mμ, using a glass cell against a blank of chloroform, according to the instructions furnished with the spectrophotometer.

5. *Calculation*

The total apparent ABS of the sample may be calculated by the formula:

$$\text{ABS (ppm)} = \text{mg/l ABS} = \frac{\text{mg ABS from calibration curve} \times 1{,}000}{\text{sample taken (ml)}}$$

BANGOR'S NEW UPLAND POND SUPPLY

BY DONALD P. JOHNSTON*

[*Read September 21, 1959.*]

Mr. Chairman and members of the New England Water Works Association: The last time I gave a paper before this organization was the Fall of 1952. The title of that paper was "History and Problems of the Bangor Water Department." We had many problems at that time. Since then we have eliminated some of them, and things are looking somewhat better at present.

As you know, Bangor, Maine, is known as the queen city of the East and is located at the head of tidewater on the Penobscot River. Since 1875 the city has taken water from the river, and since 1875 we have been plagued with pollution in one form or another. First was the sawdust and bark from the lumbering operations which made our State famous; then came the sulfites from the pulp mills which located on the river, and with it all was the ever-increasing amount of domestic sewage. Naturally the taste of the water reflected the increasing amount of chemicals added to it to keep it safe for domestic consumption; and in 1950 the Saturday Evening Post in an article on the city described the water as tasting like "rotten sawdust and moose tracks."

The different Water Boards and groups of citizens down through the years have been attempting to correct the situation with good-quality water from many of the lakes in the vicinity. Way back in 1904 a typhoid epidemic with 540 certified cases so alerted the citizens to the condition that a hearing was held before the Judiciary Committee of the State Legislature, and an Act for a Bangor Water District was signed by the Governor on March 21, 1905.

This Act and many others like it were defeated, however. Almost every major hydraulic engineering firm in the East had made a survey for us at one time or another. George Sampson

*Superintendent, Water District, Bangor, Me.

of Weston & Sampson, Paul Howard of Whitman & Howard, and Thomas Camp of Camp, Dresser & McKee are only a few of the men with whom we've had the privilege of working. We even designed a system ourselves, which was filed because a cost of 2¼ million dollars back in 1934 seemed excessive.

In 1957 a new group of energetic Trustees studied the problem. Again a new bill was written. It was approved by the State Legislature in 1957, and the Trustees went to work to see what they could do. An intensive selling campaign was launched through the newspapers, radio and television. Talks were made before the different Organizations in the City, and an informational leaflet was mailed to every water user.

The following questions together with many more were answered:

Why is a new system necessary?
What is the reason for a Bangor Water District?
What will be the total cost?
Will it mean an increase in taxes?
Do the members of the present Water Board unanimously approve of this plan?
What will happen to the present water system?
Will we have to replace our present pipes?
What are the new sources of water?
Is the proposed supply adequate?
Could some other community or District use these lakes if the referendum is rejected on May 6th?
How will its purity be protected?
Who will supervise the District?
How will the water rates be determined?
How long before the new water will be available, if the District is accepted on May 6th?
How much is it going to cost "me"?

To me, however, the most convincing part of the whole campaign came shortly before the citizens went to the polls to vote. We knew that a picture is better than many words, and we knew that there was a lot of muck and slime in the mains. To demonstrate what the river water was doing to the system, we selected a water meter which had been in service for several

years. It was placed on a table in front of the television camera and opened. With a silver spoon we then spooned out the muck and slime and placed it on the table.

The next day I had approximately 7,000 telephone calls; everyone in the city wanted his meter changed.

The campaign worked, however, and on May 6, 1957, the citizens of Bangor voted 3,340 to 690 for the following Enabling Act: The territory and people comprising the City of Bangor were created a body politic and corporate under the of Bangor Water District, the purposes of said District being to supply the inhabitants of the District with pure water for fire-prevention and protection purposes and for domestic, sanitary, commercial, industrial and other lawful purposes, to take over, control, manage and operate the water system then owned by said City of Bangor with all appurtenances thereto, to extend, increase, enlarge and improve said system, and generally to provide a water system for proper purposes and for the health, comfort and convenience of the inhabitants of the District.

The Engineers selected for the task of furnishing us with a new supply of water were Malcolm Pirnie Engineers of New York City.

Our new source is the Floods Pond drainage area, located approximately 15 miles east of Bangor. The water is clear, soft and palatable. The watershed has an area of 8.34 sq mi, of which 1.53 sq mi are water surface, including two additional ponds. The estimated dependable yield of Floods Pond is about 7.1 mgd, and this can be increased in the future by diversions from Spectacle and Beech Hill Ponds. Our present consumption is about 3½ mgd. In order to protect the source of water, the District has acquired a strip 200 ft wide completely around the periphery of Floods and Burnt Ponds.

The system includes intake and pumping facilities at the west end of Floods Pond. The intake consists of two 36-inch pipes, one in about 10 ft of water and one in about 20 ft of water. The lake water will pass through fine screens into a pump well. Four vertical, well-type, electrically driven pumps are provided, each having a capacity of 4 mgd. Two are provided with auxiliary drives. Facilities are provided at the pumping

station for chlorinating the water and for the application of lime and soda ash, to prevent excessive corrosion of cast iron mains in the distribution system. An operator's residence will be near the pumping station.

The transmission facilities include a 30-inch pipe line from Floods Pond to the Penobscot River. It is located along the northerly sides of Burnt Pond, Little Burnt Pond and Snowshoe Pond, and thence generally westerly to East Eddington. From this point the pipe has been installed in the northerly side of the Right of Way of Route 9 as far as Eddington. Two 24-inch mains cross under the Penobscot River.

On the westerly side of the River a 30-inch main extends to a pressure-reducing valve chamber at the intersection of Mt. Hope Ave. and Hogan Rd. A 24-inch line continues a short distance to junctions with the existing distribution system.

A 4-mil gal steel storage tank has been constructed on District property adjacent to the existing 2-mil gal Essex Street Storage Tank. These tanks are supplied through the existing distribution system.

The system is designed to operate automatically off the level of water in the new Essex Street Tank. Electrical impulses controlled by this level will be transmitted over leased telephone wires to the pumping station, where they will turn the pumps on and off as required. The chlorination facilities will be operated automatically from the starters of the pumps. The chemicals for corrosion control will be fed automatically by an electrical signal from the flow meter.

In case a telemeter failure occurs the operator can operate the pumps manually. In case of power failure, two pumps are provided with gasoline drives. A gasoline-driven auxiliary generator is also provided, to supply station lighting, and a radio transmitting station is provided in case of telemeter or telephone failure.

The system was financed with a $4,000,000 bond issue at an interest cost of 3.75%. Of this amount $1,290,000 is in Serial Bonds maturing through March 1, 1998, and the remainder is in Term Bonds.

RATE SCHEDULE APPLIED FOR ANNUAL FIXTURE RATES FOR WATER TO RESIDENTIAL CONSUMERS

For Use by Single Family for	
First faucet	$10.00
Each additional faucet or fixture not specifically listed herein	4.00
First Water Closet	6.00
Each additional water closet	2.20
Wash bowl, each	2.20
First bathtub, or shower not connected with bathtub	6.00
Additional bathtub, or shower not connected with bathtub, each	2.20
Laundry tub, set, including two	2.00
Laundry tub, set, over two, each	1.00
Washing machine, connected to home plumbing	4.00
Sill cock or hose held in hand	5.50
Lawn sprinkler or hose not held in hand	9.00
Garbage Disposall	4.00
Minimum rate for Residential Consumers	10.00

A cold-water fixture and hot-water fixture which empty into the same receptacle shall be considered as one fixture.

MISCELLANEOUS CONSUMERS

Circus	
Each ring, per day	$10.00
Plus cost of operating labor	

ANNUAL RATES

FIRE PROTECTION — PRIVATE SERVICE

For each fire hydrant installed on owner's premises	$60.00
For standpipes having fire-hose connections, each opening	6.00
Automatic Sprinklers	
For each four-inch connection	$20.00
For each six-inch connection	30.00
For each eight-inch connection	50.00
For 100 sprinkler heads or less	2.00
For each additional sprinkler head above 100	.02

FIRE PROTECTION — PUBLIC SERVICE

For the total 565 hydrants, including the 552 in service on mains existing on December 31, 1958, and the 13 in the completed project under construction, a total amount per year of	$89,240.00
For each hydrant on existing mains in addition to the 565 as listed, an amount per year of	160.00

Rates for hydrants installed on new mains are to be determined by the then local conditions and submitted to the Maine Public Utilities Commission for approval.

CITY PUBLIC WORKS

For city parks, winter service, including skating rinks $225.00

All fire-protection charges are to be billed quarterly in advance and payable within thirty days.

QUARTERLY AND MONTHLY RATES FOR WATER TO METERED CONSUMERS

QUARTERLY RATE

For the first	1,200 cu ft per quarter	$.50 per 100 cu ft
For next	19,800 cu ft per quarter	.22 per 100 cu ft
For next	129,000 cu ft per quarter	.20 per 100 cu ft
For next	1,350,000 cu ft per quarter	.14 per 100 cu ft
For all in excess of	1,500,000 cu ft per quarter	.10 per 100 cu ft

MONTHLY RATE

For the first	400 cu ft per month	$.50 per 100 cu ft
For next	6,600 cu ft per month	.22 per 100 cu ft
For next	43,000 cu ft per month	.20 per 100 cu ft
For next	450,000 cu ft per month	.14 per 100 cu ft
For all in excess of	500,000 cu ft per month	.10 per 100 cu ft

MINIMUM CHARGE

Size of meter (inches)	Minimum charge		Water allowance (cu ft)	
	Quarterly	Monthly	Quarterly	Monthly
⅝	$ 6.00	$2.00	1,200	400
¾	7.98	2.66	2,100	700
1	11.28	3.76	3,600	1,200
1 ½	19.20	6.40	7,200	2,400
2	29.76	9.92	12,000	4,000
3	55.50	18.50	24,000	8,000
4	79.50	26.50	36,000	12,000
6	151.50	50.50	72,000	24,000

In closing, I regret to say that the moose are fast disappearing from the Maine scene. I am not sorry, however, that we are washing the smell of his tracks from Bangor's drinking water.

MEMOIR OF HAROLD W. GRISWOLD

Harold W. Griswold, Past President of the New England Water Works Association, died at the Manchester Memorial Hospital, Manchester, Conn., on August 27, 1959, following a brief illness.

Born in Hartford, Conn. on December 21, 1886, the son of the late Frank C. and Agnes (Wiley) Griswold, he attended the Hartford public schools and graduated from Massachusetts Institute of Technology in 1908 with a B.S. degree in Civil Engineering. Except for a brief period with the Chicago & North Western Railroad immediately following graduation, Mr. Griswold worked the first five years of his professional career with the Corps of Engineers, U. S. Army, on various river-improvement projects in Alabama and Tennessee.

In June, 1913, he joined the engineering staff of the Hartford Board of Water Commissioners and continued with its successor, The Water Bureau of the Metropolitan District, until his retirement as Deputy Manager and Deputy Chief Engineer on January 1, 1947. During this period the Nepaug and Barkhamsted water-supply projects were developed. In World War I he accepted an assignment with the government to work on emergency contracts, involving the water-supply system at the Norfolk Navy Yard. Following his retirement he worked as a consultant on water-supply matters.

Mr. Griswold joined the New England Water Works Association in April, 1929. He served on numerous committees and was an active participant in all activities of the Association, of which he was President in 1945-1946. He was also a member of the American Water Works Association, the American Society of Civil Engineers and the Connecticut Society of Civil Engineers. He was a vestryman of Trinity Episcopal Church in Hartford, where he resided.

Mr. Griswold is survived by his wife, Mabel Laraway Griswold.

Harold W. Griswold was a kindly, affable man and an extremely capable engineer, who contributed much to the development and operation of the water-supply system with which he was so long associated.

WARREN A. GENTNER

PROCEEDINGS

NOVEMBER 1959 MEETING

STATLER-HILTON HOTEL, BOSTON, MASS.

THURSDAY, NOVEMBER 19, 1959

President Warren A. Gentner in the Chair.

Secretary Knox announced the election by the Executive Committee of the following new members:

Robert J. Smith, with Camp, Dresser & McKee, Boston, Mass.

Corporate

Lebanon Water Department, Lebanon, N. H.

PRESIDENT GENTNER. I know of no more fitting person to perform the next ceremony than the chairman of the Scholarship Committee, and the man who did so much towards the establishment of the Scholarship Fund—Mr. William B. Duffy. [*Applause*]

WILLIAM B. DUFFY. President Gentner, invited guests, members of the New England Water Works Association: The New England Water Works Association Scholarship Program was adopted in May, 1956. In September, 1958, at Poland Spring, Me., the first Scholarship Grant was made to Frank Wyskiel, a resident of Manchester, N. H., and a student at Cornell University, Ithaca, N. Y.

At our Lake Placid Convention in September this year, announcement was made of the second Scholarship Award. The recipient, Alan Ferry, is a Junior Member of the Association and the son of Clarence E. Ferry, a member o fthe Association and Superintendent of Distribution of the Manchester Water Works, Manchester, N. H. Alan Ferry has worked the past two summers with the Division of Sanitary Engineering of the

New Hampshire State Department of Health. He is a student at the Massachusetts Institute of Technology.

It is a great pleasure for me, on behalf of the New England Water Works Association, to present to you, Alan, this Scholarship grant of $300 and to wish you every success in your studies. [*Applause*]

ALAN FERRY. I thank you, Mr. Duffy, and thanks to you all. The only thing that you are interested in is how and where your money is being spent. As you go over Harvard Bridge and look out the window you see some worried-looking buildings; that is M.I.T., and that is where the money is going. Thank you. [*Applause*]

A paper on "The Public-Relations Program of the Water and Sewage Works Manufacturers Association" was read by George W. Kelsey, President-elect of the Water and Sewage Works Manufacturers Association, Inc., and Vice-President of B-I-F Industries, Inc., Providence, R. I.

A paper on "Financing Water-Works Construction in New England" was read by William P. Coues, Vice-President, Boston Safe Deposit & Trust Co., Boston, Mass.

A movie—"Pipe Walls without Welds"—was presented through the courtesy of the United States Steel Corp.

DECEMBER 1959 MEETING

STATLER-HILTON HOTEL, BOSTON, MASS.

THURSDAY, DECEMBER 17, 1959

President Warren A. Gentner in the Chair.

Secretary Knox announced the election by the Executive Committee of the following new members:

John H. Driscoll, Administrative Clerk, Water Department, Stoneham, Mass.; Edwin Dunbar Callahan, Superintendent

of Public Works, Stoneham, Mass.; John C. Nordeste, Jr., Superintendent, Water Department, Somerset, Mass.

Reinstated

Herbert D. Nickerson, Senior Sanitary Engineer, Massachusetts Department of Public Health, Boston, Mass.

A paper on "Experiences in the Application of Fluorides to Public Water Supplies in Northeastern Massachusetts" was read by Herbert D. Nickerson, Senior Sanitary Engineer, Massachusetts Department of Public Health, Boston, Mass.

A paper on "Observations of Water Supplies and Related Matters in Egypt" was read by J. Carrell Morris, Associate Professor of Sanitary Engineering, Harvard University, Cambridge, Mass.

A movie—"The Snows of Tutapaca"—a 16-mm sound film, was presented through the courtesy of the Lock Joint Pipe Co.

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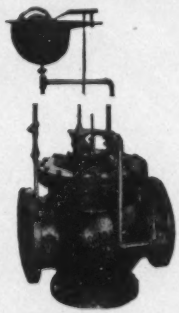

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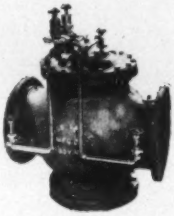

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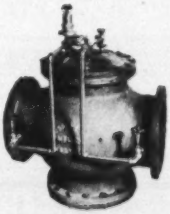

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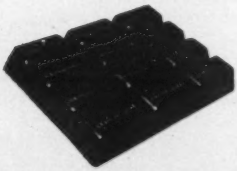

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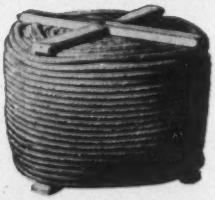

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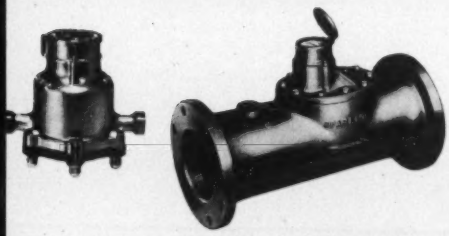

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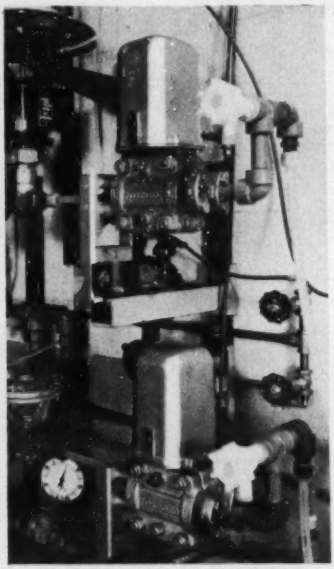

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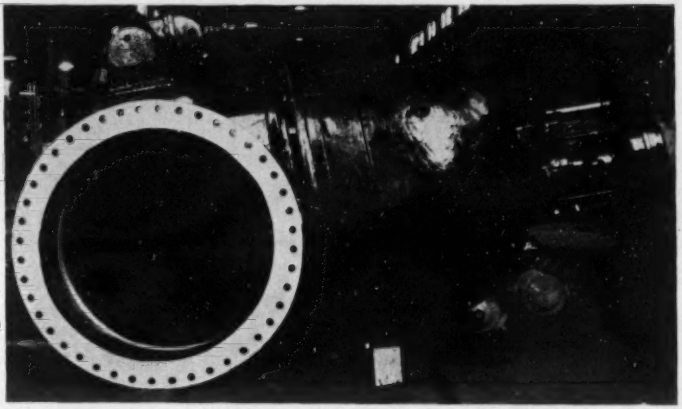

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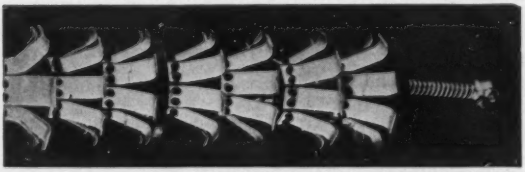

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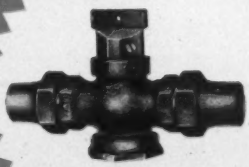

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